SECTION 16000
BASIC ELECTRICAL REQUIREMENTS

PART 1—GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, materials, tools, and equipment, and perform all work and services necessary for, or incidental, to the furnishing and installation of all electrical work as shown on the Drawings, and as specified in accordance with the provisions of the Contract Documents and completely coordinate with the work of other trades involved in the general construction. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work. The Contractor shall obtain approved Shop Drawings showing wiring diagrams, connection diagrams, roughing-in and hook up details for all equipment and comply therewith. All electrical work shall be complete and left in operating condition in accordance with the intent of the Drawings and the Specifications for the electrical work.

B. THE CONTRACTOR SHALL REFERENCE THE FUNCTIONAL DESCRIPTIONS AND OTHER REQUIREMENTS FOUND IN DIVISION 17, CONTROL AND INFORMATION SYSTEMS, FOR ADDITIONAL REQUIREMENTS PERTAINING TO WORK UNDER THIS CONTRACT. THE FUNCTIONAL DESCRIPTIONS REFERENCED HEREIN SHALL BE CONSIDERED AS PART OF THE WORK REQUIRED UNDER THIS CONTRACT.

C. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL INTERCONNECTING DEVICES, CONDUIT, WIRE, AND APPURTENANCES NOT FURNISHED BY OTHERS BUT REQUIRED FOR THE OPERATION OF EQUIPMENT AS DESCRIBED IN THE FUNCTIONAL DESCRIPTIONS WHETHER SPECIFICALLY SHOWN ON THE DRAWINGS OR NOT.

D. The scope of work for this project primarily includes, but is not limited to, the following:

1. Installation of new MCC and panelboards.
2. Installation of new dry transformer.
3. Installation of new disconnect switches.
4. Installation of new branch circuit wiring and raceways.
5. Other electrical work as specified herein and indicated on the Drawings.

E. Maintaining the operation of these facilities during the duration of the construction period is essential and required. The Contractor shall furnish and install temporary equipment as required to maintain facility operation. Reference Section 01520 of the Specifications for construction sequencing and specific operational constraint information.

F. All electrical equipment shall conform to the applicable NEMA specifications. All electrical equipment shall be properly identified in accordance with these Specifications and Contract Drawings. Nameplates shall be engraved high pressure plastic laminate, black with white• lettering for 120/208 or 120/240V equipment, and red with white lettering for 277/480 or 480V equipment. The nameplates shall be attached to the equipment cabinets with two (2) stainless steel sheet metal• screws for nameplates up to 2-inch wide. For nameplates over 2-inch wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. All panelboards, starters, control panels, cabinet enclosures, and equipment switches shall be labeled in the manner described, or in an equally approved manner.

G. All materials, equipment, sizes and capacities of electrical equipment incorporated in the project shall conform to the latest requirements of the current National Electric Code, the National Electrical Manufacturer's Association, the State and local electrical codes, and to applicable rules and regulations of the local electrical utility serving the project.

H. All material and equipment must be the product of an established and reputable manufacturer; must be new and of first class construction; must be designed and guarantteed to perform the service required; and must bear the label of approval of the Underwriters Laboratories, Inc., where such approval is available for the product of the listed manufacturer as approved by the Engineer.

I. When a specified or indicated item has been superseded or is no longer available, the manufacturer's latest equivalent type or model of material or equipment as approved by the Engineer shall be furnished and installed at no additional cost to the Owner

J. Where the Contractor's selection of equipment of specified manufacturers or additionally approved manufacturers requires changes or additions to the system design, the Contractor shall be responsible in all respects for the modifications to all system designs, subject to approval of the Engineer. The Contractor's bid shall include all costs for all work of the Contract for all trades made necessary by such changes, additions or modifications or resulting from any approved substitution.

K. Furnish and install controls for each piece of equipment requiring the controls under this Contract. The controls shall be the size and type recommended by the manufacturer for the application and as otherwise specified or indicted on the Drawings. Refer to Divisions 1 and 17 of the Specifications for control, connection and coordination descriptions and requirements.

L. Furnish and install all stands, racks, brackets, supports, and similar equipment required to properly serve the equipment which is furnished under this Contract, or equipment otherwise specified or indicated on the Drawings.

1.02 DRAWINGS

A. Conduits and wiring are shown diagrammatically only, and the layout does not necessarily show the total number of conduits for the circuits required, nor are the locations of indicated runs intended to show the actual routing of conduits. The Contractor shall furnish, install, and place in satisfactory condition ready for operation, all conduits, cables, and all other material needed for the complete lighting, power, and other electrical systems shown or indicated in the Contract Documents. Additional

conduits and the required wiring shall be installed by the Contractor for wherever needed to complete the installation of the specific equipment furnished, at no additional cost to the Owner.

1.03 EQUIPMENT LOCATION

A. The Drawings show the general location of feeders, transformers, outlets, conduits, and circuit arrangements. Because of the small scale of the Drawings, it is not possible to indicate all of the details involved. The Contractor shall carefully investigate the structural and finish conditions affecting all of his work and shall arrange such work accordingly; furnishing such fittings, junction boxes, and accessories as may be required to meet such conditions. The Contractor shall refer to the entire Drawing set to verify openings, special surfaces, and location of other equipment, or other special equipment prior to roughing-in for panels, switches, and other outlets. The Contractor shall verify all equipment dimensions to insure that proposed equipment will fit properly in spaces indicated.

B. The electricity to the Haneman Environmental Park is provided by the landfill gas to energy facility. Atlantic City Electric does not own any utility poles on the site. Connections will be coordinated with Energenic (previously DCO) who is the ACUA's partner with the gas-to-energy facility.

Energenic Contact Info: John Farls – Electrical Engineer
Phone: (609) 837-8000

1.04 LOCAL CONDITIONS

A. The Contractor shall examine the site and become familiar with conditions affecting the work. He shall investigate, determine, and verify locations of any overhead or buried utilities on or near the site, and shall determine such locations in conjunction with all public and/or private utility companies and with all authorities having jurisdiction. All costs, both temporary and permanent to connect all utilities, shall be included in the Bid. The Contractor shall be responsible for scheduling and coordinating with the local utility for temporary and permanent services.

B. In addition, the Contractor shall relocate all duct banks, lighting fixtures, receptacles, switches, boxes, and other electrical equipment as necessary to facilitate the Work included in this project at no additional cost to the Owner.

1.05 SUBMITTALS

A. The Contractor shall submit to the Engineer Shop Drawings of all electrical materials, apparatus, appliances, equipment and miscellaneous devices shown or specified and shall be in accordance with the requirements of the General Conditions.

B. Shop Drawings shall be sufficiently complete in detail to enable the Engineer to determine compliance with Contract requirements. Details and information shown shall include but are not necessarily limited to the following:

1. Performance characteristics.

2. Physical sizes.

3. Material and equipment specifications, and construction and methods of fabrication details.

4. Compliance with standards (e.g. UL, NEMA), rules, regulations, and codes.

5. Accessories.

6. Complete wiring diagrams showing circuit designations as shown on the Drawings. A complete wiring diagram shall be submitted for each controller furnished.

7. Complete product data sheets for all components of the specified equipment.

8. Electrical ratings (voltage, current, KVA; phase, etc.)

9. Weights of components parts and assembled unit weights.

10. Complete assembly, layout, and installation drawings with clearly marked dimensions.

C. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

D. Shop Drawings will be approved only to the extent of the information shown. Approval of an item of equipment shall not be construed to mean approval for components of that item for which Contractor has provided no information.

E. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment' specification section.

F. Each submittal shall be identified by the applicable specification section.

1.06 APPLICABLE CODES AND REQUIREMENTS

A. Conformance

1. All work, equipment and materials furnished shall conform with the existing rules, requirements and specifications of the Insurance Rating Organization having jurisdiction, the serving electrical utility company, the latest edition of the National Electrical Code (NEC), the National Electric Manufacturers Association (NEMA), the Institute of Electrical and Electronic Engineers (IEEE), the Insulated Power Cable Engineers Association (IPCEA), the American Society of Testing Materials (ASTM), the American National Standards Institute (ANSI), the requirements of the Occupational Safety Hazards Act (OSHA), and all other applicable Federal, State and local laws and/or ordinances.

2. All material and equipment shall bear the inspection labels of Underwriters Laboratories, Inc., if the material and equipment is of the class inspected by said laboratories.

3. All work shall be in accordance with local codes.

B. Nonconformance

1. Any paragraph of requirements in these Specifications, or Drawings, deviating from the rules, requirements and Specifications of the above organizations shall be invalid and their (the above organizations) requirements shall hold precedent thereto. The Contractor shall be held responsible for adherence to all rules, requirements and specifications as set forth above. Any additional work or material necessary for adherence will not be allowed as an extra, but shall be included in the Bid Price. Ignorance of any rule, requirement, or Specification shall not be allowed as an excuse for nonconformity. Acceptance by the Engineer does not relieve the Contractor from the expense involved for the correction of any errors, which may exist in the drawings submitted, or in the satisfactory operation of any equipment.

C. Certification

1. Upon completion of the work, the Contractor shall obtain certificate(s) of inspection and approval from the National Board of Fire Underwriters or similar inspection organization having jurisdiction and shall deliver same to the Engineer and the Owner.

1.07 PERMITS AND INSPECTIONS

A. The Contractor shall reference the General Conditions and Section 01010, Summary of Work.

1.08 TEMPORARY LIGHTING AND POWER

A. The Contractor shall reference the General Conditions.

1.09 TESTS

A. Upon completion of the installation, the Contractor shall perform tests for operation, load (Phase) balance overloads, and short circuits. Tests shall be made with and to the satisfaction of the Owner and Engineer.

B. The Contractor shall perform all field tests and shall provide all labor, equipment, and incidentals required for testing and shall pay for electric power required for the tests. All defective material and workmanship disclosed shall be corrected by the Contractor at no cost to the Owner. The Contractor shall show by demonstration in service that all circuits and devices are in good operating condition. Test shall be such that each item of control equipment will function not less than five *(5)* times.

C. The grounding system shall be tested to assure continuity and compliance with the requirement that ground resistances do not exceed *5* ohms when measured by a

megohmeter or equivalent device. Ground resistance measurements of each grounding electrode shall be taken and certified by the Contractor. Upon completion of the Project, the Contractor shall submit to the Engineer the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding (system as well as the resistance and soil conditions at the tithe the measurements were made. Ground resistance measurements shall be made in normally dry weather not less than 48 hours after rainfall and with the ground under test isolated from other grounds. Ground resistance shall also be measured from each piece of equipment to the grounding electrode. Reference Section 16170, Grounding and Bonding, for additional requirements.

D. Each lighting and power distribution panelboard shall be tested with main circuit breaker disconnected from the feeder, branches connected, branch circuit breakers closed, all fixtures in place and permanently connected; lamps removed or omitted from the fixtures, and all wall switches closed.

E. Testing (Insulation Resistance Test) of all incoming and outgoing cables for switchgears, distribution and power panels, motor control centers, and similar equipment shall be done after the cables are in place and just prior to final terminations. All data shall be recorded, as per Exhibit "A", attached to the end of this Section.

F. The Contractor shall furnish all equipment and personnel as required.

G. Feeder circuits shall be tested with the feeder conductors disconnected from the supplied equipment. Each individual power circuit shall be tested at the panel or motor control center with the power equipment connected for proper operation.

H. Megohmmeter tests of the insulation resistance of rotating machines and power feeders shall be conducted. The results will be accepted when the megger shows the insulation resistance to be not less than one megohm per 100 volts at 10°C using a 1,000-volt megger.

I. All transformers shall be Megohmmeter tested in accordance with the manufacturer's recommendations.

1.10 DOCUMENTATION

A. Required Documentation

1. The work requirements of this Section is in addition to and does not supersede testing and adjusting specified in other portions of the Contract Documents. The Contractor shall submit to the Engineer test records and reports for all testing.

1.11 FIELD TEST OF EQUIPMENT

A. The equipment to be tested shall include, but not be limited to, the following:

1 Panelboards

2. Conduit System

3. Cable and Wire

4. Grounding System

5. General Purpose Dry Type Transformers

B. Refer to each specific specification section for detailed field tests.

1.12 FINAL FIELD TEST OF SYSTEM

A. The Contractor shall complete the installation and testing of the electrical installation at least two (2) months prior to the start-up and testing of all other equipment. During the period between the completion of electrical installation and the start-up and testing of all other equipment, the Contractor shall make all components of the Work available as it is completed for their use in performing Preliminary and Final Field Tests.

B. Before each test commences, the Contractor shall submit a detailed test procedure, and also provide test engineer resume, manpower and scheduling information for the approval by the Engineer. In addition, the Contractor shall furnish detailed test procedures for any of his equipment required as part of the field tests of other systems.

C. The Contractor shall perform an infrared inspection to locate and connect all heating problems associated with electrical equipment. The infrared inspection shall apply to existing and new equipment.

1.13 PROTECTIVE DEVICE SETT'ING AND TESTING

A. When the power studies has been completed and approved (reference Article 1.16 in this Section), the Contractor shall provide the services of a qualified testing company using N.E.T.A. certified technicians to adjust, set, calibrate and test all protective devices in the electrical system. The qualifications of the testing company and resumes of the technicians as well as all data forms to be used for the field testing shall be submitted.

B. All protective devices in the electrical equipment, shall be set, adjusted, calibrated and tested in accordance with the manufacturers recommendations, the coordination study, and best industry practice.

C. Proper operation of all equipment associated with the device under test and its compartment shall be verified, as well as complete resistance, continuity and polarity tests of power, protective and metering circuits. Any minor adjustments, repairs and/or lubrication necessary to achieve proper operation shall be considered part of this Contract.

D. All solid state trip devices shall be checked and tested for setting and operation using manufacturers recommended test devices and procedures.

E. Circuit breakers and/or contactors associated with the above devices shall be tested for trip and close functions with their protective device.

F. When completed, the Contractor shall provide a comprehensive report on all equipment tested indicating condition, readings, faults and/or deficiencies in same. Inoperative or defective equipment shall be brought immediately to the attention of the Engineer.

G. Prior to placing any equipment in service, correct operation of all protective devices associated with this equipment shall be demonstrated by field testing under simulated load conditions.

1.14 SCHEDULES AND PLANT OPERATIONS

A. Since the testing required in 1.12 above shall require that certain pieces of equipment be taken out of service, all testing procedures and schedules must be submitted to the Engineer for review and approval one month prior to any work beginning. When testing has been scheduled, the Engineer must be notified forty-eight hours prior to any work to allow time for load switching and/or alternation of equipment. In addition, all testing that requires temporary shutdown of plant equipment must be coordinated with the Owner/Engineer so as not to affect proper plant operations.

B. At the end of the workday, all equipment shall be back in place and ready for immediate use should a plant emergency arise. In addition, should an emergency condition occur during testing, at the request of the Owner, the equipment shall be placed back in service immediately and turned over to plant personnel.

C. In the event of accidental shutdown of plant equipment, the Contractor shall notify plant personnel immediately to allow for an orderly restart of affected equipment.

1.15 MATERIALS HANDLING

A. Materials arriving on the job site shall be stored in such a manner as to keep material free of rust and did, and so as to keep material properly aligned and true to shape. Rusty, dirty, or misaligned material shall be rejected. Electrical conduit shall be stored to provide protection from the weather and accidental damage. Rigid non-metallic conduit shall be stored on even supports and in locations not subject to direct sun rays or excessive heat. Cables shall be sealed, stored, and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather. Adequate protection shall be required at all times for electrical equipment and accessories until installed and accepted. Materials damaged during shipment, storage, installation, or testing shall be replaced or repaired in a manner meeting with the approval of the Engineer. The Contractor shall store equipment and materials in accordance with Section 01550, Site Access and Storage.

1.16 POWER SYSTEM STUDIES

A. General

1. The Contractor shall provide Short Circuit Studies, Protective Device Evaluation Studies, and Protective Device Coordination Studies performed by a professional registered electrical engineer currently registered in the State of New Jersey for the entire electrical system. The studies shall be performed in accord4nce with 399-1990, IEEE Recommended Practice for Industrial and Commercial System Power Analysis (IEEE Brown Book). The studies shall be submitted to the

ENGINEER prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacture. If formal completion of the studies may cause delay in equipment manufacture, approval from the ENGINEER may be obtained for a preliminary submittal of sufficient study data to insure that the selection of device ratings and characteristics will be satisfactory.

2. The studies shall include all portions of the electrical distribution system from the existing outdoor main over-current protective device, the normal power sources including the existing operations building switchboard. The study shall also include the 480.volt over-current protective devices for each feeder. The study shall include all MCCs and panelboards affected by this work. System connections and those which result in maximum fault conditions shall be adequately covered in the study.

3. In the event that the short circuit study requires a higher interrupting and/or withstand rating of equipment than that which is indicated in the Contract Documents, the Contractor shall furnish and install the equipment as required based on the study with no extra cost to the OWNER.

4. In the event that the protective device coordination study indicates that different settings or equipment is required than that which is specified, the Contractor shall furnish and install the equipment based on the study with no extra cost to the OWNER.

B. Data Collection for the Studies

1. The Contractor shall provide the required data for preparation of the studies. The preparer of the studies shall furnish the CONTRACTOR with a listing of the required data immediately after award of the Contract.

2. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to release of the equipment for manufacture.

3. The following limited information was gained from the electric utility during the design period and could be used for the purpose of the power system studies. Inclusion of this information, however, does not relieve the Contractor nor his suppliers of the responsibility of obtaining all the necessary information required to perform the study. The Contractor shall complete the following form and include it in the submittal package.

PROJECT OR STRUCTURE/BUILDING NAME

Threephase Fault at Service Connection Point:

kVa kA X/R ratio X% R%

Line-to-Neutral Fault at Service Connection Point:

_kVa kA _XlRratio _X% _R%

Utility's Transformer Data

Capacity (kVA)

Voltage (Primary Secondary)

Windings Connection (NY, Y/Y, etcj *ñVIjjt9jJ5jê%*

Nominal Impedance (%)

C. Short Circuit Study and Protective Device Evaluation Study

1. The short circuit study shall be performed with the aid of a digital computer program and shall be in accordance with IEEE Std. 399-1990 and IEEE Std. 141-1993.

2. The study input data shall include the utility company's short circuit contribution, resistance and reactance components of the branch impedances, the X/R ratios, base quantities selected, and other source impedances. Reference Section 16495 - Variable Frequency Drives of these Specifications.

3. Short circuit close and latch duty values and interrupting duty values shall be calculated on the basis of assumed three-phase bolted short circuits at each bus, switchgear, medium and low voltage motor control center, distribution panelboard, pertinent branch circuit panel mid other significant locations through the system. The short circuit tabulations shall include symmetrical fault currents, and XIR ratios. For each fault location, the total duty on the bus, as well as the individual contribution from each connected branch, shall be listed with its respective X/R ratio.

4. A protective device evaluation study shall be performed to determine the adequacy of circuit breakers, molded case switches, automatic transfer switches and fuses by tabulating and comparing the short circuit ratings of these devices with the calculated fault currents. Appropriate multiplying factors based on system X/R ratios and protective device rating standards shall be applied. Any problem areas or inadequacies in the equipment due to short circuit currents shall be promptly brought to the attention of the ENGINEER.

5. All equipment furnished shall meet the requirements of this study; with no extra cost to the OWNER.

D. Protective Device Coordination Study

1. A protective device coordination study shall be performed to provide the necessary calculations and logic decisions required to select or to check the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low voltage circuit breaker trip characteristics and settings.

2. The coordination study shall include all low voltage classes of equipment from the utility company service protective devices down to and including the main circuit breakers of motor control centers. The phase and ground over current protection shall be included as well as settings of all other adjustable protective devices.

3. The time-current characteristics of the specified protective devices shall be drawn on log-log paper. The plots shall include complete titles, representative one-line diagram and legends, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low voltage circuit breaker trip curves and fuses. The coordination plots shall indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing inrush and ANSI transformer withstand parameters, cable thermal over current withstand limits and significant symmetrical and asymmetrical fault currents. All restrictions of the National Electrical Code shall be adhered to and proper coordination intervals and separation of characteristic curves shall be maintained. The coordination plots for phase and ground protective devices shall be provided on a system basis. A sufficient number of separate curves shall be used to clearly indicate the coordination achieved.

4. The selection and settings of the protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios and connections, manufacturer and type, range of adjustment and recommended settings. A tabulation of the recommended power fuse selection shall be provided for the medium voltage fuses where applied in the system. Any discrepancies, problem areas, or inadequacies shall be promptly brought to the attention of the ENGINEER.

E. Study Report

1. The results of the power system studies shall be summarized in a report. The report shall be submitted to the Engineer. The report shall be submitted for review and acceptance prior to submittals for medium voltage switchgear, medium voltage motor control equipment, low voltage switchgear and switchboards, motor control centers, variable frequency drives, panelboards, and similar electrical equipment.

2. The report shall include the following sections:

   a. Description, purpose, basis and scope of the study and a detailed single line diagram with 'nodes" cross-referenced to the calculated values tabulated in the study report of that portion of the power system which is included within the scope of the study.
   b. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties and commentary regarding same.
   c. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
   d. Fault current calculations including a definition of terms and guide for interpretation of computer printout.

3. Prior to commencing the work, the preparer the studies shall meet with the testing firm that will do the relay field testing and the Owner's representative at the site for a walk through of the facility to insure that existing conditions are taken into account.

4. The study shall include a detailed explanation of all software programs and procedures used to arrive at the calculated, values, settings, and drawings (e.g. single line diagrams) showing fault valves at all busses

PART 2—PRODUCTS

2.01 PRODUCT REQUIREMENTS

A. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

B. All items of the same type or ratings shall be identical. This shall be further understood to include products with the accessories indicated

C. All equipment and materials shall be new, unless indicated or specified otherwise.

D. The Contractor shall submit proof if requested by the Engineer that the materials, appliances, equipment, or devices that he provides under this Contract meet the requirements of Underwriters Laboratories, Inc., iii regard to fire and casualty hazards. The label of or listing by the Underwriters Laboratories, Inc., will be accepted as conforming with this requirement

2.02 SUBSTIUTIONS

A. Any reference in the Specifications or on the Drawings to any article, service, product, material, fixture, or item of equipment by name, make, or catalog number shall be interpreted as establishing the type, function, and standard of quality and shall not be construed as limiting competition. Any proposed substitution and or-equal item shall be submitted to the Engineer a minimum of 14 days prior to the bid for review and evaluation.

2.03 CONCRETE

A. The Contractor shall furnish all concrete required for the installation of all electrical work, Concrete shall be Class A unless otherwise specified, and in complete conformance with the applicable requirements of Division 3 of the Specifications.

B. The Contractor shall provide concrete equipment pads for all free standing electrical apparatus and equipment located on floors or slabs that are existing or provided by others. The Contractor shall provide all necessary anchor bolts, channel iron sills, etc. The exact location and dimensions shall be coordinated for each piece of equipment well

in advance of the scheduled placing of these pads. Equipment pads shall be 4 inches high unless otherwise indicated on the Drawings. Pads shall be reinforced with steel wire mesh and shall have dowel rods inserted into the floor for anchorage.

C. The Contractor shall provide concrete foundations for all free standing electrical apparatus and equipment located outdoors or where floors or slabs are not existing or provided by others. The Contractor shall provide all necessary anchor bolts, channel iron sills, etc. The location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of the foundations. Equipment foundations shall be constructed as detailed on the Drawings or if not detailed on the Drawings shall be 6 inches thick minimum reinforced with #4 bars at 12-inch centers each way placed mid-depth. Concrete shall extend 6 inches minimum beyond the extreme of the equipment base and be placed on a compacted stone bed *(#57* stone or ABC) 6 inches thick minimum.

D. Concrete and reinforcing steel shall meet the appropriate requirements of Division 3 of the Specifications.

PART 3—EXECUTION

3.01 CUTTING AND PATCHING

A. Coordination

1. The work shall be coordinated between all trades to avoid delays and unnecessary cutting, channeling and drilling. Sleeves shall be placed in concrete for passage of conduit wherever possible.

2. The Owner's electrical supervisor shall review the location of all proposed penetrations in floors and walls prior to drilling. No penetrations shall be made without written approval of same by the Owner's electrical supervisor.

B. Damage

1. The Contractor shall perform all chasing, channeling, drilling and patching necessary to the proper execution of his Contract. Any damage to the building or any equipment shall be repaired by qualified mechanics of the trades involved at the Contractor's expense. If, in the Engineer's judgment, the repair of damaged equipment would not be satisfactory, then the Contractor shall replace damaged equipment at his own expense.

3.02 EXCAVATION AND BACKFILLING

A. The Contractor shall perform all excavation and backfill required for the installation of all electrical work. All excavation and backfilling shall be incomplete accordance with the applicable requirements of Division 2.

3.03 CORROSION PROTECTION

A. Wherever dissimilar metals, except conduit and conduit fittings, come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

END OF SECTION

SECTION 16110
RACEWAYS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This Section includes all conduits installed under this Contract. The work shall include:

1. Conduits.

2. Fittings.

3. Junction boxes.

B. The minimum size conduit of any type shall be 3/4 inch unless otherwise shown on the Contract Drawings or authorized by the Engineer in writing.

1.02 SUBMITTALS

A. Descriptive literature and technical information relative to the conduit system, underground ducts and manhole appurtenances shall be submitted by the Contractor in conformance with the requirements of Section 16000 - Basic Electrical Requirements.

1.03 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed shop tests. None required.

2. Field tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

b. All conduit shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of suitable pulling tape.

1.04 REFERENCES

A. All conduits shall comply with the requirements of Section 16000 - 1.07 Applicable Codes and Requirements.

1.05 DELIVERY, STORAGE, HANDLING AND IDENTIFICATION

A. Conduits shall be delivered to the job site in standard bundles having each length suitably marked with the manufacturer's name and trademark and bearing the label of the UL Inc. inspection service.

PART 2 - PRODUCTS

2.01 METAL CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Alfiex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Manhattan/CDT/Cole-Flex.
7. Maverick Tube Corporation.
8. O-Z Gedney; a unit of General Signal.
9. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.l.

C. IMC: ANSI C80.6.

D. EMT: ANSI C80.3.

E. FMC: Zinc—coated steel or aluminum.

F. LFMC: Flexible steel conduit with PVC jacket.
LFNC: Flexible Liquidtight Nonmetallic Conduit

G. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB I; listed for type and size raceway with which used, and for application and environment in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Steel or die-cast, set-screw or compression type.
3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.

H. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.02 NONMETALLIC CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group.
6. Condux International, Inc.
7. EleeSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.

C. ENT: NEMATCI3.

D. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

E. LFNC: UL 1660.

F. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

G. Fittings for LFNC: UL 514B.

2.03 FLEXIBLE METALLIC CONDUIT

A. Flexible metallic conduit shall be liquid tight having a core of flexible, galvanized steel tubing covered with a liquid-tight polyvinyl jacket. Tubing shall be fined with grounding

bushings and standard rigid conduit fittings for connection and attachment. Conduit shall be UL listed.

B. Conduit shall be manufactured by Electric-Flex Company, Type HTA, Anaconda, or equal.

2.04 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to pro e firm and uniform sup for conduit. Prepare trench bottom for conduit

2. Install backfill as specified in Division 2 Section 'Earthwork.'

3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 2 Section "Earthwork."

4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

6. Warning Planks: Bury, warning planks approximately 12 inches above direct-buried conduits, placing them 24 inches o.c. Align planks along the width and along the centerline of conduit.

2.05 INSTALLATION OF UNDERGROUND HANDROLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes and boxes with bottom below the frost line, 30" below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated, Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

2.06 OUTLET BOXES AND FITTINGS

A. Outlet boxes and fittings shall be of proper dimensions for each application, complete with watertight gaskets and covers secured with stainless steel screws.

B. Conduit fittings, such as elbows, tees couplings, caps, bushings, nipples, and locknuts shall be threaded to provide a watertight connection.

C. Joints in conduit and between conduit and fittings shall be watertight and ends shall be reamed to prevent damage to conductor insulation. Joints shall be made with standard couplings, Erikson couplings or watertight unions.

D. A non-corrosive, conductive thread lubricant such as "STL" thread lubricant as manufactured by Crouse-Hinds shall be thoroughly applied on all threaded joints.

E. Cast metal outlet boxes shall be Crouse-Hinds Company, Appleton Electric Company or equal, and shall be coated inside and outside with corrosion-resisting epoxy or equal finish.

F. All junction boxes, fittings or other terminals without tapped conduit entrances shall be provided with double nuts and standard bushings. Running thread unions will not be permitted

G. Where conduits pass through expansion joints, approved weatherproof telescopic type expansion fittings shall be used. Fittings shall be OZ/GEDNEY Type AX, watertight and permit a movement up to 4 inches and shall be equipped with approved bonding jumpers around or through each fitting. Bonding jumpers shall be Appleton, Crouse-Hinds, OZ/Gedney, or Thomas and Betts Equivalent.

H. Conduit fittings ("condulets") shall be used on exposed conduit work for lighting and power outlets, convenience outlets, changes in direction of conduit runs and breaking around beams. "Condulets" shall be cast ferrous alloy, galvanized or cadmium plated, as manufactured by Crouse-Hinds, OZ/Gedney, or Appleton Company. Epoxy coated fittings and boxes shall be used with coated conduit in all chemically aggressive areas or where called for on the Drawings. Covers shall be of a design suitable for the purpose intended. In damp areas, the outside condulets shall be made watertight. Install all condulets with the covers accessible. Use proper tools to assemble conduit system to prevent injury to the plastic covering. No damage to the covering shall be permitted.

2.07 TERMINAL, JUNCTION AND PULL BOXES

A. Terminal, junction, and pull boxes shall be installed as required.

B. Boxes made of stainless steel shall be used, unless otherwise specified. Where the weight of cast boxes exceed 50 pounds, boxes may be made of 1/8 inch sheet stainless steel, with sides flanged around the cover opening or with approved supporting frame for cover.

Mounting lugs and threaded entry bosses shall be provided as required. Seams in sheet metal boxes shall be continuously welded and ground smooth.

C. Pull and junction boxes shall have covers held in place by stainless steel screws. Terminal boxes shall have minimum 12 gauge steel panels for mounting terminal blocks. Hinged covers shall fit tightly against a gasket, secured by lug bolts and wing nuts. All boxes shall be provided with rabbeted gaskets or flange gaskets, securely held in place.

D. All junction, terminating and pull boxes shall be of sufficient size to provide free space for all conductors enclosed and in accordance with the latest NEC Code Articles 370 and 373.

E. Conduits shall be terminated with approved rigid conduit hubs. Conduit hubs shall have "0" rings for a water tight seal.

F. Cast metal terminal, junction, and pull boxes shall be Crouse-Hinds Company, Appleton Electric Company or equal.

G. Boxes shall be complete with all terminal blocks as required.

H. In hazardous locations, all terminal, junction and pull boxes shall be rated NEMA Type7

2.08 EXPANSION JOINT FITTINGS

A. This Contractor shall furnish and install expansion joints in each conduit run to coincide with the expansion joints installed under the associated structural contract. Each joint shall provide a minimum of 4 inch expansion or contraction.

B. Each joint shall be installed with ground jumper and two bonding clamps, to insure a continuous ground in each run. Expansion fittings shall be as manufactured by O.Z. Gedney, Appleton or equal.

PART 3 - EXECUTION

3.01 CONDUIT SYSTEMS, FI1TINGS, AND BOXES

A. All conduits shall be installed as required. The conduit system shall be installed complete with all accessories, fittings, and boxes, in an approved and, workmanlike manner to provide proper raceways for electrical conductors.

B. The Contractor shall note that all conduit runs shown on the Contract Drawings are shown diagrammatically for the purpose of outlining the general method of routing the 4 conduits to avoid interferences.

C. Ml new conduits shall have a mandrel pulled through to remove any burrs or sharp edges that might destroy the integrity of the conductor.

D. As far as practicable, conduit shall be pitched slightly to drain to the junction boxes, or otherwise installed to avoid trapping of condensate. Where necessary to secure drainage, a Crouse-Hinds Company Type ECD, Universal, Appleton Electric Company ECDB, or equal breather-drain fitting shall be installed in the boxes or trapped cond it at low points.

Conduit shall not be run through columns or beams unless so specifically detailed on the Contract Drawings.

E. Factory-made conduit bends or elbows shall be used wherever possible in making necessary changes in direction. Field bends shall be carefully made to prevent conduit damage or reduction in internal areas. The bending radius shall not be less than six times the nominal diameter of the conduit with carefully matched bends on parallel runs to present a neat appearance. The number of crossovers shall be kept to a minimum.

F. Conduit system bends and offsets may be made in field using approved bending tools, but no deformed, split or crushed conduit will be permitted in the work. All bends in conduit over 1 inch in diameter shall be made with pipe bending machine. No more than three quarter bends shall be made between any two pull boxes without permission of the Engineer.

G. Junction boxes shall be supported independently of the conduits entering it using approved supports and mounting hardware.

3.02 EXPOSED CONDUIT

A. Installation

1. All exposed conduits shall be run parallel to or at right angles to walls or beams, and plumb on the walls.

2. The conduit system shall be installed complete with all accessories, fittings and boxes in an approved manner to provide proper raceways for electrical conductors.

3. All conduits cut on the job shall be carefully reamed after threading, to remove burrs.

4. All threads shall be tapered. No running threads will be permitted. Threads on steel conduit shall be given a coat of zinc dust in oil or other approved compound.

5. All conduits shall be carefully cleaned before and after installation and all inside surfaces shall be free of imperfections likely to damage the cable. After installation complete conduit runs shall be snaked with an approved tube cleaner.

6. A 1/8 inch nylon or polypropylene fish wire shall be added to conduits for pulling cable.

7. All threaded joints shall be watertight and shall insure a low resistance ground path in the conduit system.

8. Exposed conduit runs extending through building expansion joints shall be installed with expansion-type fittings, the same size as the conduit.

9. Exposed conduits shall be supported in an approved manner. Conduits shall not be fastened to or come in contact with any mechanical system pipes, ducts, or equipment of other trades except where approved.

10. In all exposed conduit work, approved channels, racks, one-hole straps, or a combination thereof shall be used as supports. Where conduits are supported with one-hole straps, spacers shall be used to provide 1/4 inch minimum clearance between the conduits and supporting surfaces. Perforated strap hangers will not be accepted.

3.03 CONDUIT TERMINATIONS

A. The conduit system shall terminate at the terminal box or at the conduit connection point of electric motors, devices and equipment. Termination of conduits at such locations shall permit direct wire connections to motors, devices, or equipment.

B. Conduit connections shall be made with rigid conduit if the equipment is fixed and not subject to adjustment, mechanical movement, or vibration. Rigid conduit connections shall have union fittings, to permit removal of equipment without cutting or breaking of the conduit.

C. Conduit connections shall be made with approved flexible metallic conduit if the equipment is subject to adjustment, mechanical movement or vibration. Flexible conduit connections shall be watertight.

3.04 CONDUITS AND FITTINGS

A. Unless otherwise specified herein or indicated on the Drawings, the minimum size conduit shall be 3/4 inch for exposed work and 1 inch for conduit encased in concrete or mortar.

B. Where exposed, maintain a minimum distance of 6 inches from parallel runs of flues or water pipes. Conduit runs shall be installed in such locations as to avoid steam or hot water pipes. A minimum separation of 12 inches shall be maintained where conduit crosses or parallels hot water or steam pipes.

C. For floor mounted equipment, conduit may be run overhead and dropped down, where under floor installation is not practical. Groups of conduits shall be uniformly spaced, where straight and at turns. Conduit shall be cut with a hacksaw or an approved conduit-cutting machine and reamed after threading to remove all burrs. Securely fasten conduit to outlets, junction and pull boxes to effect firm electrical contact. Join conduit with approved couplings. Conduits shall be freed from all obstructions.

D. Empty conduit systems shall be furnished and installed as indicated on the Drawings and shall have pull wires installed. The pull wire shall be No. 14 AWG zinc-coated steel, or plastic material, having not less than 200 pound tensile strength. Not less - than 12 inches of slack shall be left at each end of the pull wire.

E. Each piece of conduit installed shall be free from blisters or other defects. Each piece installed shall be cut square, taper reamed, and a coat of sealing compound applied to threads. Threads on conduits shall be painted with a conducting compound prior to

making up in a fitting Conduit connections shall be made with standard coupling and the ends of the conduit shall butt tightly into the couplings. In exposed work only, where standard coupling cannot be used, only Erickson couplings are permitted, or as otherwise acceptable to the Engineer.

F. Conduit threaded in the field shall be of standard sizes and lengths.

G. All bends shall be made with standard factory conduit elbows or field bent elbows. Field bending of conduit shall be done using tools approved for the purpose. Heating of conduit to facilitate bending is prohibited. Field bends shall be not less than the same radius than a standard factory conduit elbow. Bends with kinks shall not be acceptable. The equivalent number of 90 degree bends in a single conduit run is limited to the following:

1. Runs in excess of 300 feet: 0

2. Runs of 300 feet to 201 feet: 1

3. Runs of 200 feet to 101 feet: 2

4. Runs of 100 feet and less: 3

H. Unless otherwise specified herein, indicated on the Drawings, or required by the NEC, conduit shall be supported every 8 feet and shall be installed parallel with or perpendicular to walls, structural members, or intersections of vertical planes and ceilings with right angle turns consisting of fittings or symmetrical bends. Conduits shall be supported within 1 foot of all changes in direction. Supports shall be approved pipe straps, wall brackets, hangers or ceiling trapeze. Perforated sfrap hangers shall not be used. In no case shall conduit be supported or fastened to another pipe or installed to prevent the removal of other pipe for repairs. Fastenings shall be by expansion bolts on concrete; by machine screws, welded threaded studs, or spring-tension clamps on steel work. Explosive-drive equipment may be used to make connections where the use of this equipment complies with safety regulations. Wooden plugs inserted in masonry and the use of nails as fastening media are prohibited. Threaded C-clamps may be used on rigid steel conduit only. Conduits or pipe straps shall not be welded to steel.

I. The load applied to fasteners shall not exceed 1/4 of the proof test load. Fasteners attached to concrete ceilings shall be vibration and shock resistant. Holes cut to a depth of more than 1-1/2 inches in reinforced concrete beams or to a depth of more than *3/4* inch in concrete joints shall not cut the main reinforcing bars. Holes not used shall be filled. Spring steel fasteners may only be used to support lighting branch circuit conduits to structural steel members. Conduits shall be fastened to all sheet metal boxes and cabinets with two (2) locknuts where required by the National Electrical Code to insure adequate bonding for grounding. Where insulated bushings are used, or where• bushings cannot be secured firmly to the box or enclosure, a bonding jumper shall, be installed •to maintain suitable grounding continuity. Locknuts shall be the type with sharp edges for digging into the wall of metal enclosures. Bushings shall be installed on the ends of all conduits and shall be of the insulating type where' required by the National Electrical Code.

J. No more than three (3) 90 degree bends will be allowed in any one conduit run. Where more bends are necessary, a condulet or pull box shall be installed. All bends in *1/2-inch*

and 3/4-filch conduit shall be made with a conduit bender, and all larger sizes shall have machine bends. Joints in threaded conduit shall be made up watertight with the appropriate pipe thread sealant or compound applied to male threads only; and, all field joints shall be cut square, reamed smooth, and properly threaded to receive couplings. No running threads are permitted. All conduit ends at switch and outlet boxes shall be fined with an approved locknut and bushing forming an approved tight bond with box when screwed up tightly in place.

K. Conduits stubbed up through concrete floors for connections to freestanding equipment and for future equipment shall be provided with an adjustable top or coupling threaded inside for plugs, set flush with the finished floor. Wiring shall be extended in rigid metal conduit to equipment except that, where required, flexible metal conduit may be used 6 inches above the floor. Screwdriver operated threaded flush plugs shall be installed in conduits from which no equipment connections are made.

L. Where outlets are shown near identified equipment furnished by this or other Contractors, it is the intent of the Specifications and Drawings that the outlet be located at the equipment to be served. The Contractor shall coordinate the location of these outlets to be near the final location of the equipment served whether placed correctly or incorrectly on the Drawings. Changes in outlet locations required to serve the equipment furnished by other Contractors on the Project shall be brought to the attention of the Engineer.

M. Conduit shall be protected immediately after installation by installing flat non-corrosive metallic discs and steel bushings, designed for this purpose, at each end. Discs shall not be removed until it is necessary to clean, the conduit and install the conductors: Before the conductors are installed, insulated, bushings shall be installed at each end of the conduit.

N. Where "all-thread" nipples are used between fittings and electrical equipment, they shall be so installed that no threads are exposed.

O. Connections from rigid conduit to motors and other vibrating equipment, limit switches, solenoid yalves, level controls, and similar equipment, shall be made with short lengths of liquid-tight flexible metal conduit. These conduits shall be installed in accordance with the NEC and shall be furnished and installed with appropriate connectors with devices, which will provide an excellent electrical connection between the equipment and the rigid conduit for the flow of ground current. Flexible C metal conduit and liquid-tight flexible metal conduit length shall be five feet (5 feet), maximum.

P. Flexible metal conduit or liquid-tight flexible metal conduit installed between rigid metal conduit and motor terminal box and/or any other apparatus shall have a green insulated grounding conductor running through flexible conduit. This conductor shall be terminated to the nearest pull box, motor terminal box, or any other apparatus ground terminal.

Q. All threaded ends of conduits shall be coated with an approved conducting compound as manufactured by Thomas & Betts, or equal prior to making up the joint.

R. Conduits installed within or underneath floor slabs, underground direct-buried or concrete encased conduits, and all conduits installed in areas subject to liquid inadvertently entering the conduit system shall be sealed or plugged at both ends in

accordance with NEC Article 300-5(g). This requirement applies to both conduits containing conductors and "spare" conduits. Where practicable, the interior of the conduit shall be sealed as well as around the conductors by. using conduit sealing bushings: Type CSB as manufactured by O/Z Gedney, or Crouse Hinds equivalent. Where the conduit fill does not allow the use of these bushings, the conduits shall be tightly caulked or plugged. Conduits passing through sleeves in interior walls and floors shall be tightly caulked.

S. Weatherproof, insulated throat "Meyers" hubs shall be used on all conduit entries to boxes and devices without integral hubs in process areas to maintain NEMA 4X integrity. The Contractor shall furnish and install "Meyers" hubs on all conduit entries into non-cast enclosures such as metallic or non-metallic control panels, control component enclosures, wireways, pull boxes, junction boxes, control stations, and similar type equipment when this type of equipment is located in process areas requiring NEMA 4X integrity. This specified requirement for "Meyers" hubs does not apply to any area of the plant facilities where NEMA 4X integrity is not required.

T. The use of two (2) locknuts and a grounding bushing shall be required at all conduit terminations where hub type fittings are not required; such as electrical rooms, control rooms, and office areas.

U. Conduit installation shall be arranged to minimize cleaning. No horizontal runs of conduit will be permitted in brick or masonry walls.

V. Unless specifically identified on the Drawings as "Direct Buried," all conduits in the earth outside of the structure shall be concrete encased. Joints in conduit shall be staggered so as not to occur side by side.

3.05 CONDUIT USES AND APPLICATIONS

A. Conduit application table: The following table shows what conduit types are to be applied in each area:

Area Description	Conduit Type
Conduits run exposed indoors in the Truck Wash Area or in the area of the wash equipment in the Equipment Room	PVC
Conduits run exposed outdoors	PVC or PVC Coated Rigid Galvanized Steel
Conductors run inside the Storage area and Equipment room on the opposite wall from the wash equipment	EMT, Rigid Steel or PVC Coated Rigid Galvanized Steel
Conduits run in ductbank or underground	PVC Schedule 80
Conduits run direct bury in concrete floor	PVC

END OF SECTION

SECTION 16119
UNDERGROUND DUCTS AND UTILITY STRUCTURES

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. Furnish and install complete underground raceway systems as shown on the Contract Drawings and as specified herein, all in accordance with the requirements of the Contract Documents.

1.02 SUBMITTALS

A. Submit shop drawings for the following:

1. Underground conduit sections

   a. Conduit sizes, types, and manufacturer
   b. Spacer placement
   c. Location of other existing electrical conduits and their proximity to proposed conduits
   d. Location of other existing gas, water, or process lines and their proximity to proposed conduits.

2. Cable pull calculations:

   a. Provide cable pulling calculations for all of the underground conduit runs shown on the Contract Drawings for power, signal, and control conductors to ensure that the cable runs do not exceed the manufacturer's sidewall pressure. See Section 16123 for additional requirements.

PART 2 - PRODUCTS

2.01 UNDERGROUND CONDUITS AND FITTINGS

A. Refer to Section 16110

PART 3 - EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Excavation and backfill shall be in accordance with Section 02222 "Excavation and Backfill for Utilities". Crushed stone shall be used for bedding of concrete encased ducts and manholes.

3.02 DUCT BANK INSTALLATION

A. The greatest practicable separation shall be maintained at all times from other utilities. At least three inches of earth separation shall be maintained between proposed conduits and other pipes, ducts, etc.

B. Plastic spacers shall be set every 5 feet and anchored to prevent movement during concrete placement.

C. Any conduit which does not require conductors, shall have a 1/8-inch polypropylene pull cord installed throughout the entire length of the raceway.

D. Metal warning tape conduit markers shall be installed every 20 feet along each run of underground conduit, at changes in horizontal direction of the underground conduit, and at the ends of the underground conduit.

END OF SECTION

SECTION 16123
BUILDING WIRE AND CABLE

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, connect, test, and place in satisfactory operating condition, ready for service, all cables and wires indicated on the Drawings and as specified herein or required for proper operation of the installation, with the exception of internal wiring provided by electrical equipment manufacturers. The work of connecting cables to equipment, machinery, and devices shall be considered a part of this Section. All hardware, junction boxes, bolts, clamps, insulators, and fittings required for the installation of cable and wire systems shall be furnished and installed by the Contractor.

B. The Contractor shall submit Shop Drawings and other material required to substantiate conformance with the requirements set forth on the Drawings and in Section 16000, Basic Electrical Requirements, and Article 6 of the General Conditions. Shop drawings shall include, but not be limited to, detailed specifications and product data sheets for the power, control, and instrumentation cable required for this project.

C. The wire and cable to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing wire and cable for a minimum often (10) years.

D. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

A. All testing shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witness Shop Tests

   a. Not required.

2. Shop Test

   a. Prior to the first shipment of each size of power, control, and instrumentation cable to be furnished and installed under this Contract, samples of each size of cable shall be subjected to complete physical and electrical factory production tests at the manufacturer's plant. Other cable and wiring shall be tested in accordance with the applicable ICEA Standards. Six copies of certified test data sheets shall be submitted to the Engineer for approval prior to installation at the site. Subsequent shipment of each size of wire shall be covered by certificates of compliance which shall list Contractor's name, point of delivery, reel numbers, size of wire, length of wire, and date of shipment. Certificates shall attest the wires and cables comply with specification requirements and that wires and cables are equal in every respect to wires and cables which have been successfully tested.

b. All test data or certificates shall be submitted.

3. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

b. After installation, all wires and cables shall be tested for insulation levels and continuity. Insulation resistance between conductors of the same circuit and between conductor and ground shall be tested. Testing for insulation levels shall be as follows:

1. For 600V power and control cable, apply 1,000 VDC from a Megaohmeter for all 600V wires and cables installed in lighting, control, power, indication, alarm and motor feeder circuits. Testing for continuity shall be "test light" or "buzzer".
2. 600V instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 260 volt-ohmmeter, or equal. The resistance value shall be 200 Megaohms or greater.

B. Low voltage wires and cables shall be tested before being connected to motors, devices or terminal blocks.

C. Voltage tests shall be made successively between each conductor of a circuit and all other conductors of the circuit grounded.

D. If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner.

E. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the wire and cable manufacturer and submit the following:

1. Shop Drawings

2. Reports of Certified Shop and Field Tests

3. Wiring Identification Methods

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed material's compliance with the Contract Documents.

B. Partial, incomplete, or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Material specifications and product data sheets.

2. Cable pulling calculations.

3. Wiring identification methods and materials.

1.05 IDENTIFICATION

A. Each cable shall be identified as specified in Part 3, Execution, of this Specification.

1.06 CABLE PULLING LUBRICANTS

A. The Contractor shall submit a list with a minimum of four manufacturer's standard lubricants which may be used interchangeably for each type of lubricant required. Lubricant shall be non-hardening type.

1.07 CABLE PULL CALCULATIONS

A. The Contractor shall submit cable pulling calculations. These calculations, to be performed by a currently registered professional engineer in the State of New Jersey, shall define pulling tension and sidewall loading (sidewall bearing pressure values) for all installations of 600 VAC, #1/0 conductors and larger greater than 200 feet in length. Calculations for straight horizontal installations of 600 VAC, #1/0 conductors and larger (greater than 200 feet are not required

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The wire and cable covered by this Specification is intended to be standard equipment of proven performance as manufactured by the Okonite Company, Rome Cable Corporation, Southwire4Dompany, or equal. Wire and cable shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings. Only one manufacturer for each wire and cable type shall be permitted.

2.02 600 VOLT POWER WIRE AND CABLE

A. 600 volt cable and wire shall consist of stranded, copper conductor with insulation rated THHN, 90°C for dry locations and THWN, 75°C for wet locations.

B. Conductors shall be tin or alloy coated (if available), stranded copper per ASTM-B8 and B-33, and Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be No. 12 AWG.

C. Uncoated conductors shall only be allowed if specifically accepted by the Engineer.

D. 600 volt individual power wire and cable shall be Okoseal-N as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal. Multi-conductor power cables shall be Okoseal-N Type TC Cable as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal.

2.03 600 VOLT CONTROL CABLE

A. 600 volt control cable shall consist of stranded, copper conductor with insulation rated THHN, 90°C for dry locations and THWN, 75°C for wet locations. The individual conductors of the multiple conductor cable shall be color coded for proper identification. Color coding shall be equal to ICEA SL68514, Table K-i. Cables shall meet requirements of IEEE-3 83.

B. Conductors shall be tin or alloy coated (if available) stranded copper per ASTM B-Sand B-33, and Class B or C stranding contingent on the size unless otherwise specified. Minimum wire size shall be No 16 AWG

C. Uncoated conductors shall only be allowed if specifically accepted by the Engineer.

D. 600 volt individual conductor control wire shall be Okoseal-N as manufactured by the Okonite Company, Rome Cable Corporation equivalent Southwire Company equivalent, or equal. Multi-conductor control cable shall be Okoseal-N Type TC Cable as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal.

2.04 INSTRUMENTATION CABLE

A. The instrumentation cable for analog signals shall be single, shielded, twisted pairs or triads with 600 volt insulation and shall have a 90°C insulation rating.

B. Conductors shall be tin or alloy coated (if available), soft, annealed copper, stranded per ASTM-B8, Class B stranding unless otherwise specified. Minimum size wire shall be No. 16AWG.

C. The instrumentation cable shall be Okoseal-N Type P-OS for single pair or triad applications and Okoseal-N Type SP-OS for multiple pair or triad applications as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal.

PART 3 - EXECUTION

3.01 600V CABLE INSTALLATION

A. The cable and wires shall be installed as specified herein and shown on the Drawings.

B. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.

C. To minimize oxidation and corrosion, wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for "copper-to-copper" connections. The compound shall be Penetrox E as manufactured by Bundy Electrical, or equal.

D. Splices shall not be allowed in the underground duct, manhole and handhole systems. If splices are required, the Contractor shall obtain approval in writing from the Engineer prior to splicing. Splicing materials shall be barrel type buff splice connectors and heat shrink tubing as manufactured by 3M, Ideal, or equal. No splicing of instrumentation cable is allowed.

E. Wire and Cable Sizes

1. The sizes of wire and cable shall be as shown on the Drawings, or if not shown, as approved by the Engineer. If required due to field routing, the size of conductors and respective conduit shall be increased so that the voltage drop does not exceed 2-1/2%.

2. Minimum wire size within control panels, motor control centers, switchboards and similar equipment shall be No. 12 AWO for power and No. 16 AWG for control.

F. Number of Wires

1. The number of wires indicated on the Drawings for the various control, indication, and metering circuits were determined for general schemes of control and for particular indication and metering systems.

2. The actual number of wires installed for each circuit shall, in no case, be less than the number required; however, the Contractor shall add as many wires as may be required for control and indication of the actual equipment selected for installation at no additional cost to the Owner. The addition of conductors shall be coordinated with and approved by the Engineer to avoid violations of the NEC regarding conduit fill.

3. All spare field conductors shall be terminated on the terminal blocks mounted within the equipment.

G. Wiring Identification

1. All wiring shall be identified at each termination, shall have a unique wire number, and shall be labeled at both ends. Wire numbers shall correspond with the equipment terminal wire numbers as indicated in the accepted Shop Drawings. Where no wire numbers are indicated, the Contractor shall advise the Engineer in writing prior to assigning wire numbers. Wire numbers shall not be duplicated.

2. In addition to color coding, for all 1 -phase and 3-phase systems, identify each cable (single or multi-conductor) and conductor at each end, in each manhole,

pullbox, cable tray, or other component of the raceway system. This identification is applicable to all power, control, alarm, signal, and instrumentation cables, and conductors

3. Identify each cable (single or multi-conductor) and groups or bundles of individual single conductors in each manhole, pullbox, cable tray or other component of the raceway system with circuit identification markers. Implement a "from-to" cable/conductor bundle tagging system as part of this identification effort.

4. For instrumentation wiring, the Contractor shall provide, on the Shop Drawings, a schedule indicating the wire number, color code, if applicable, origin and destination devices, and terminals.

5. Wire identification shall be accomplished through the use of a portable printer and white, polyolefin wire marking sleeves. The wire identification system shall be a "Bradymarker' XC Plus Printer with "Bradysleeve' wire marking sleeves, Panduit equivalent, Seton equivalent, or equal.

6. The Contractor shall submit a written description outlining his intended method of wiring identification and supporting information (i.e., product data sheets, etc.) identifying the materials to be used. The Contractor shall meet with the Owner and the Engineer to come to an agreement regarding wire identification prior to the installation of any wiring.

H. Cable Identification Tags

1. The Contractor shall furnish all labor and materials and affix in a permanent way to each cable in manholes, cable compartments and vaults, junction boxes, pull boxes and points of termination, a bronze metal tag, 1/2-inch in diameter, with a 1/8-inch diameter hole, with copper wire through the hole, the cable identification number approved by the Engineer. The tag shall be attached to the cable by twisting the ends of the copper wires. All cables shall be tagged with its full ID number immediately after it has been pulled.

I. Cable Installation

1. All interior cable not protected by a compartment enclosure shall be run in conduit.

J. Wiring Supplies

1. Only electrical wiring supplies manufactured under high standards of production and meeting the approval of the Engineer shall be used.

2. Rubber insulating tape shall be in accordance with ASTM Des. D119. Friction tape shall be in accordance with ASTM Des. D69.

K. Training of Cable

1. The Contractor shall furnish all labor and material required to train cables around cable vaults within buildings and in manholes and handholes in the outdoor underground duct system. Sufficient length of cable shall be provided in each handhole, manhole, and vault so that the cable can be trained and racked in an approved manner. Instrumentation cable shall be racked separate from all other AC and DC wiring to maintain the required separation specified herein. In training or racking, the radius of bend of any cable shall be not less than: the manufacturer's recommendation. All manhole cables shall be arc and fire-proofed. The training shall be done in such a manner as to minimize chaffing.

L. Connections at Control Panels, Limit Switches, and Similar Devices

1. Where stranded wires are terminated at panels, and/or devices, connections shall be made by solderless lug, crimp type ferrule, or solder dipped.

2. Where enclosure sizes and sizes of terminals at limit switches, solenoid valves, float switches, pressure switches, temperature switches, and other devices make 7-strand, No. 12 AWG, wire terminations impractical, the Contractor shall terminate external circuits in an adjacent junction box of proper si2e and shall install No. 14 AWG stranded wires from the device to the junction box in a conduit. The #12 AWG field wiring shall also be terminated in the same junction box to complete the circuit.

M. Pulling Temperature

1. Cable shall not be flexed or pulled when the temperature of the insulation or of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with ah ambient temperature within a three day period prior to pulling of 40°F or lower, cable reels shall be stored during the three day period prior to pulling in a protected storage area with an ambient temperature not lower than 55°F and pulling shall be completed during the work day for which the cable is removed from the protected storage.

N. Color Coding

1. Conductor insulation shall be color coded as follows:

a. 480V AC Power
Phase A – BROWN
Phase B – ORANGE
Phase C – YELLOW
Neutral – GRAY

b. 120/208V or 120/240V AC Power
Phase A-BLACK
Phase B – RED
Phase C- BLUE
Neutral – WHITE

c. DC Power
Positive Lead – RED
Negative Lead – BLACK

d. DC Control

All wiring – BLUE

e. 120VAC Control Single conductor 120 VAC control wire shall be RED except for a wire entering a motor control center compartment or control panel which is an interlock. This conductor shall be color coded YELLOW.

f. 24VAC Control
All wiring – ORANGE

g. Equipment Grounding Conductor
All wiring – GREEN

2. Conductors No.2 AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape.

3.02 INSTRUMENTATION CABLE INSTALLATION

A. The Contractor shall install all cable or conductors used for instrumentation wiring (4-20 mA DC, etc.) in rigid galvanized steel or PVC coated rigid galvanized steel conduit. The use of asbestos cement or plastic conduit will not be permitted. Analog signal wires shall exclusively occupy these conduits. No other wiring for AC or digital DC circuits shall be installed in these conduits.

B. All shielding shall be continuous and shall be grounded in accordance with the instrumentation equipment manufacturer's recommendations, as approved.

C. A raceway containing instrumentation cable shall be installed to provide the following clearances:

1. Raceway installed parallel to raceway conductors energized at 480 through 208 volts shall be 18 inches and 208/120 volts shall be 12 inches.

2. Raceway installed at right angles to conductors energized at 480 volts or 120/208 volts shall be 6 inches.

D. Where practical, raceways containing instrumentation cable shall cross raceway (containing conductors of other systems at right angles.

E. Where instrumentation cables are installed in panels, manholes, handholes, and other locations, the Contractor shall arrange wiring to provide maximum clearance between these cables and other conductors. Instrumentation cables shall not be installed in same bundle with conductors of other circuits.

F. Grounding of cable shield shall be accomplished at one point ànly, unless otherwise required by instrumentation system's manufacturer.

G. Additional pullboxes shall be furnished and installed for ease of cable pulling and the cable manufacturer's recommended conduit fill factor shall be followed. Where required for specifically directed by the Engineer, the Contractor shall moisture seal the cables at all connections with OZ Gedney Type "CSB", or equal, sealing bushings.

H. Special instrument cable shall be as specified or recommended by the vendor of the equipment or instruments requiring such wiring. Installation, storage, terminations, etc., shall be per manufacturer's recommendations.

I. All cable, insulation and jacket shall have adequate strength to allow for it to be pulled through the conduit systems. Sufficient conductors shall be installed to provide space and serve future equipment where shown and specified. All conductors shall be color coded and all wires shall be suitably tagged with permanent markers at each end.

END OF SECTION

SECTION 16130
BOXES

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, materials, tools and equipment necessary for furnishing, installing, connecting, testing and placing into satisfactory operation all pull, junction and outlet boxes for power, lighting and control as required for a complete electrical installation as shown on the Drawings and specified herein.

B. Coordination

1. The Contractor shall review installation procedures under other Divisions and coordinate them with the Work specified herein.

2. The Contractor shall notify others in advance of the installation of the Work included herein to provide them with sufficient time for the installation and coordination of interrelated items that are included in the Contract and that must be installed in conjunction with the Work included in this Division.

C. Boxes shall conform to all applicable Federal, UL and NEMA standards. Materials and components shall be new and conform to grades, qualities and standards as specified herein and shown on the Drawings.

D. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Test

a. None required.

2. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer(s) and submit the following:

1. Shop Drawings

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Material specifications and product data sheets

2. Complete assembly, layout, and installation drawings for each box with clearly marked dimensions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 PULL, JUNCTION, AND OUTLET BOXES

A. Indoors

1. Pull and junction boxes for indoor exposed use in wet or damp locations shall be stainless steel with neoprene gasketed screwed-on covers and of all welded construction or PVC (if using PVC conduit) with neoprene gasketed screwed-on covers.

2. Pull and junction boxes for indoor exposed use in dry locations shall be galvanized sheet steel boxes with screw-on covers.

B. Miscellaneous

1. The Contractor shall finish and install enclosures for housing interfacing and transition equipment, or other equipment requiring an enclosure. The Contractor shall be responsible for mounting the enclosure. The enclosures shall be a low profile type, weatherproof, lockable, and securely mounted to a concrete support pad using anchoring devices by Unistrut, Kindorf, B-Line Systems, Jnc., or equal. The enclosures shall be furnished and installed in complete compliance with the NEC and with all state and local codes. The single door enclosure shall be finished with light gray epoxy paint and shall be manufactured by Hoffman, Rittal, The Austin Company, or equal.

2. All welded, galvanized, sheet steel boxes with neoprene gasketed screwed-on covers may be used outdoors in non-hazardous areas only where specified herein or indicated on the Drawings.

3. For outdoor and indoor wet process area use, NEMA 4X junction and pull boxes shall be provided. Boxes shall be equipped with neoprene gasketed covets which have been crossed ribbed and checkered. Boxes shall be provided with removable covers. Stainless steel cover screws are required. Boxes shall match the conduit to which attached.

4. For boxes shown or required in hazardous locations, boxes shall be furnished and installed in accordance with the Class, Division, and Group suitable for the application.

C. Box Sizes

1. The minimum size of boxes shall be according to the NEC. No box shall be filled to more than 40% of capacity.

D. Banlers

1. Galvanized steel or aluminum barriers shall be provided injunction or pull boxes to isolate conductors of different voltages and functions. Isolation shall be provided between the following groups:

   a. Power (480 and 120 volts)
   b. Control wiring
   c. Instrumentation wiring (twisted, shielded pairs or triads)

2. Barriers shall be provided in multi-gang outlet boxes when the voltage between switches exceeds 300 VAC.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Junction and Pull Boxes

1. All junction boxes and pull boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Wooden plugs are not permitted for securing boxes to concrete. Sidewalk-type boxes shall be cast into concrete structures and shall be flush with concrete services after installation.

2. Where control wires must be interconnected in a junction box, terminal strips, consisting of an adequate number of screw type terminals shall be installed. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected. Approximately 20 percent of the total amount of terminals provided shall consist of spare terminals. Terminals shall be lettered and/or numbered to conform with the wiring diagrams.

3. All junction boxes and pull boxes shall have identifying nameplates attached, which when installed on sidewalk type boxes shall not extend above the surrounding concrete slabs. All boxes shall be indicated and identified on the as-built drawings.

END OF SECTION

SECTION 16140
WIRING DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Receptacles with integral surge suppression units.
4. Wall-box motion sensors.
5. Isolated-ground receptacles.
6. Snap switches and wall-box dimmers.
7. Wall-switch and exterior occupancy sensors.
8. Communications outlets.
9. Cord and plug sets.
10. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

B. Related Sections include the following:

1. Division 16 Section "Voice and Data Communication Cabling" for workstation outlets.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Field quality-control test reports.

F. Operation and Maintenance Data: For, wiring devices to include in all manufacturers packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations. Cord and Plug Sets: Match equipment requirements.

PART 2-PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).

2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

3. Leviton Mfg. Company Inc. (Leviton).

4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

A. Conyenience Receptacles, 125 V, 20 A: Comply with NEMA WD I, NEMA WD 6 configuration 5-20R; and UL 498.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Cooper; 5351 (single), 5352 (duplex).
b. Hubbell; HBL5351 (single), CR5352 (duplex).
c. Leviton; 5891 (single), 5352 (duplex).
d. Pass & Seymour; 5381 (single), 5352 (duplex).

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Cooper; GF2O.
b. Pass & Seymour; 2084.

2.4 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, size as shown on drawings: Comply with NEMA WD 1, NEMA WD 6.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Cooper; L520R.
b. Hubbell; HBL231O.
c. Leviton; 2310.
d. Pass & Seymour; L520-R.

2.5 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.

2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.6 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A;

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

   a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
   b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
   c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
   d. Pass & Seymour; 2OAC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).

C. Pilot Light Switches, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

   a. Cooper; 222 1PL for 120 V and 277 V.
   b. Hubbell; HPL1221PL for 120 V and 277 V.
   c. Leviton; 1221-PLR for 120 V, 122 1-7PLR for 277.V.
   d. Pass & Seythour; PS2OAC1-PLR for 120 V.

2. Description: Single pole, with neon—lighted handle, illuminated when switch is "ON."

D. Key-Operated Switches, 120/277 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

   a. Cooper; 2221L.
   b. Hubbell; HBLI22IL.
   c. Leviton; 122 l-2L.
   d. Pass & Seymour; PS2OAC1-L.

2. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

   a. Cooper; 1995.
   b. Hubbell; HBL1557.
   c. Leviton; 1257.

d. Pass & Seymour; 1251.

F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Cooper; 1995L.
b. Hubbell; HBLI557L.
c. Leviton; 1257L.
d. Pass & Seymour; 1251L.

2.7 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable rotary knob; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

1. 600 W; dimmers shall require no derating when ganged with other devices.

D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.8 OCCUPANCY SENSORS

A. Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Cooper; 6111 for 120 V, 6117 for 277 V.
b. Hubbell; WS1277.
c. Leviton; ODS 10-ID.
d. Pass & Seymour; WS3000.
e. Watt Stopper (The); WS-200.

2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft..

B. Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Hubbell; ATI2O for 120 V, AT277 for 277 V.
b. Leviton; ODS 15-ID.

2. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft..

C. Long-Range Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Hubbell; ATDI600WRP.
b. Leviton; ODWI2-MRW.
c. Watt Stopper (The); DT-200.

2. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft..

D. Exterior Occupancy Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2. Products: Subject to compliance with requirements, provide one of the following:

a. Leviton; PS200-10.
b. Watt Stopper (The); EW-100-120.

3. Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot detection range. Minimum switch rating: 1 000-W incandescent, 500-VA fluorescent.

2.9 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Stainless Steel.

2. Material for Finished Spaces: Stainless Steel.

3. Material for Unfinished Spaces: Galvanized steel Smooth, high-impact thermoplastic.

4. Material for Damp Locations: CARLON E98TSC or equal, and listed and labeled for use in "wet locations."

5. Material for finished spaces, Brushed 304 stainless steel.

B. Wet-Location, CARLON E98TSC or equal, and listed and labeled for use in "wet locations."

2.10 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Round, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

2.11 POKE-THROUGH ASSEMBLIES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the, following:

1. Hubbell Incorporated; Wiring Device-Kellems.

2. Pass & Seymour/Legrand; Wiring Devices & Accessories.

3. SquareD/ Schneider Electric.

4. Thomas & Betts Corporation.

5. Wiremold Company (The).

B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.

1. Service Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jacks.

2. Size: Selected to fit nominal 3-inch cored holes in floor and matched to floor thickness.

3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.

4. Closure Plug: Arranged to close unused 3-inch cored openings and reestablish fire rating of floor.

5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, 4-pair, Category Se voice and data communication cables.

2.12 MULTIOUTLET ASSEMBLIES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Hubbell Incorporated; Wiring Device-Kellems.

2. Wiremold Company (The).

B. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturers standard finish.

D. Wire: No. 12AWG.

2.13 FINISHES.

A. Color: Wiring device catalog numbers in Section Text do not designate device color.

1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.

2. Wiring Devices Connected to Emergency Power System: Red.

3. TVSS Devices: Blue.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:

1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.

3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

3. The length of flee conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.

2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.

7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.

8. Tighten unused terminal screws on the device.

9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.

2. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Electrical Identification."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.

2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132.V.

2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.

3. Ground Impedance: Values of up to 2 ohms are acceptable.

4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

5. Using the test plug, verify that the device and its outlet box are securely mounted.

6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Test straight blade for the retention force, of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz..

END OF SECTION

SECTION 16145
LIGHTING CONTROL DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following lighting control devices:

1. Lighting control panels
2. Time switches.
3. Outdoor and indoor photoelectric switches.
4. Indoor occupancy sensors.
5. Outdoor motion sensors.
6. Lighting contactors.

B. Related Sections include the following:

1. Division 16 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Area Lighting Research, Inc.; Tyco Electronics.
2. Grasslin Controls Corporation; a GE Industrial Systems Company.
3. Intermatic, Inc.
4. Leviton Mfg. Company Inc.
5. Lightolier Controls; a Genlyte Company.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Paragon Electric Co.; Invensys Climate Controls.
8. Square D; Schneider Electric.
9. TORK.
10. Touch-Plate, Inc.
11. Watt Stopper (The).

B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Configuration: DPDT.
2. Contact Rating: 30-A inductive or resistive, 277 V ac.
3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.

4. Astronomic Time: All channels.

5. Battery Backup: For schedules and time clock.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Area Lighting Research, Inc.; Tyco Electronics.

2. Grasslin Controls Corporation; a GE Industrial Systems Company.

3. Intermatic, Inc.

4. Lithonia Lighting; Acuity Lighting Group, Inc.

5. Novitas, Inc.

6. Paragon Electric Co.; Invensys Climate Controls.

7. Square D; Schneider Electric.

8. TORK.

9. Touch-Plate, Inc.

10. Watt Stopper (The).

B. Description: Solid state, with DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.

2. Time Delay: 15-second minimum, to prevent false operation.

3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category Al locations.

4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.3 INDOOR PHOTOELECTRIC SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Allen-Bradley/Rockwell Automation.
2. Area Lighting Research, Inc.; Tyco Electronics.
3. Eaton Electrical Inc; Cutler-Hammer Products.
4. Grasslin Controls Corporation; a GE Industrial Systems Company.
5. Intermatic, Inc.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. MicroLite Lighting Control Systems.
8. Novitas, Inc.
9. Paragon Electric Co.; Invensys Climate Controls.
10. SquareD; Schneider Electric.
11. TORK.
12. Touch-Plate, Inc.
13. Watt Stopper (The).

B. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.

1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from tile relay unit.
2. Relay Unit: Dry contacts rated for 20 -A ballast load at 120- and 277-V ac, for 13 -A tungsten at 120-V ac, and for I hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
3. Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
4. Time Delay: Adjustable from *5* to 300 seconds to prevent cycling, with deadband adjustment.
5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.4 INDOOR OCCUPANCY SENSORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Hubbell Lighting.
2. Leviton Mfg. Company Inc.
3. Lithonia Lighting; Acuity Lighting Group, Inc.
4. Novitas, Inc.
5. RAB Lighting, Inc.
6. Sensor Switch, Inc.
7. TORK.
8. Watt Stopper (The).

B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off; adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. Mounting:
    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.

C. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.

2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.5 LIGHTING CONTACTORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following;

1. Allen-Bradley/Rockwell Automation.

2. ASCO Power Technologies, LP; a division of Emerson Electric Co.

3. Eaton Electrical Inc.; Cutler-Hammer Products.

4. GE Industrial Systems; Total Lighting Control.

5. Grasslin Controls Corporation; a GE Industrial Systems Company.

6. Hubbell Lighting.

7. Lithonia Lighting; Acuity Lighting Group, Inc.

8. MicroLite Lighting Control Systems.

9. Square D; Schneider Electric.

10. TORK.

11. Touch-Plate, Inc.

12. Watt Stopper (The).

B. Description: Electrically operated and mechanically held, combination type with complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).

2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.

3. Enclosure: Comply with NEMA 250.

4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.6 LIGHTING CONTROL PANEL

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1 Lutron

2. GE Industrial Systems; Total Lighting Control.

3. MicroLite Lighting Control Systems.

4. Square D; Schneider Electric.

B. Description: Networkable low voltage lighting control system with location and quantity of panels as indicated on the drawings.

1. Panel Hardware:

a. Backbox: Manufactured from code gauge steel, with no knockouts and partitions to separate the low and high voltage compartments.
b. Chassis: Pre-assembled to contain all relays, electronics and power supply.
c. Trim: Surface mounted trim painted to match rest of enclosure. Trim shall contain a display window for viewing status with door closed.
d. Power Supply: Dual rated power supply transformer which shall provide all power for the panel.
e. Relays: Each controlled circuit shall be connected through a single pole, single throw mechanically latching relay. The relay shall be equipped with an actuator button which extends out to allow manual operation of the contacts.
f. Load Contacts: Load contacts shall be rated as follows: 20A, 277VAC for fluorescent, tungsten and HID fixtures.

2. Panel Electronics: Each panel shall contain an electronics chassis with removable circuit cards that provides the capabilities specified below

a. Relay Output Modules (ROM): Each panel shall contain one or two ROM. Each ROM shall provide the ability to contain 24 loads, and shall continuously monitor the position of its associated loads, providing true status indication, command failure, and unexpected load change alarms, An LED shall indicate the position of each connected load.

b. Switch Input Modules (SIM): Each panel shall contain one or two SIM. Each SIM shall provide the ability to read 24 dry contact closures from wall switches, building automation systems, photo controllers or occupancy sensors. Each input shall be self-powered with no external transformer required, and shall be user selectable in one of the modes above. An LED shall indicate when each input is closed.

c. Network Control Module (NCM): Each panel shall contain one NCM. The NCM shall contain the micro—processor that controls each panel. It shall contain the necessary circuitry to communicate with other panels on the network, and shall contain the operating firmware to allow each panel to operate independently should a network failure occur. All time schedules and switch input assignments shall reside in the NCM. Failure of the network shall not prevent the operation of time schedules residing in any panel.

3. Control Capabilities: Each panel shall provide the following features

a. Selectable Switch Inputs: Each switch input shall be user definable as one of the following modes:

1) Maintained Input
2) Momentary Input
3) Time delay
4) Pulse Accumulator
5) External
6) Alarm
7) Interlock

b. Memory Loss Protection: Memory shall be protected by lithium battery backed non-volatile memory in the event of a power failure. Backup time shall be ten years.

c. Real Time Clock: A digital clock shall provide time of day, day of week and date. Automatic leap year adjustment and selectable daylight savings time adjustments shall he provided.

d. Astronomical Clock

e. Time/Event Scheduling: Schedule capacity shall be large enough to allow each load to be programmable for up to 12 events per day. Separate schedules shall be provided for each of the seven days of the week and for three special day schedules

f. Occupant Warning: Each load shall be programmable to provide a warning blink prior to each scheduled "OW' time. Occupant warning time shall be adjustable between 5 and 30 minutes.

2.7 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 16 Section "Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 16 Section "Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 16 AWG. Comply with requirements in Division 16 Section "Conductors and Cables."

PART 3 – EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 LIGHTING CONTROL PANEL INSTALLATION

A. Install the lighting control equipment according to the manufacturer's written instructions

B. Lighting control panel shall be connected and programmed to operate lights in corridors and general areas based on time-of-day and occupancy sensing controls.

3.4 WIRING INSTALLATION

A. Wiring Method: Comply with Division 16 Section "Conductors and Cables." Minimum conduit size shall be 3/4 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpowerlimited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

A. Identify components and power and control wiring according to Division 16 Section "Electrical Identification."

1. Identify controlled circuits in lighting contactors.

2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.

2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions, Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owners maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION

SECTION 16170
GROUNDING AND BONDING

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install grounding systems complete in accordance with the minimum requirements established by Article 250 of the NEC. Article 250 of the NEC shall be considered as a minimum requirement for compliance with this Specification.

B. Grounding of all instrumentation and control systems shall be furnished and installed in accordance with the manufacturer/system requirements and WEE 1100-92, Powering and Grounding of Sensitive Electronic Equipment. Conflicts shall be promptly brought to the attention of the Engineer.

C. In addition to the NEC requirements, building structural steel columns and chemical storage tanks shall be permanently and effectively grounded:

D. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

   a. None required.

2. Field Tests

   a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division I, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Reports of certified field tests.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

2. Drawings and written description of how the Contractor intends to furnish and install the grounding system.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by these specifications shall be standard equipment of proven performance as manufactured by reputable concerns Equipment shall be designed, constructed, and installed in accordance with the best practice the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 FITTINGS

A. Grounding connections to equipment shall be bolted. Cable end connections may be made by use of the crucible weld process or bolted type connectors. Bolted type connectors, for this application shall consist of corrosion resistant copper alloy with silicone bronze bolts, nuts and lockwashers which are designed for this purpose.

2.03 GROUNDING CONDUCTORS

A. A green, insulated equipment grounding conductor, which shall be separate from the electrical system neutral conductor,, shall be furnished and installed for all circuits. Equipment grounding conductors shall be furnished and installed in all conduits Use of conduits as the NEC required equipment grounding Conductor is not acceptable.

2.04 EQUIPMENT GROUNDS

A. Equipment grounds shall be solid and continuous from a connection at earth to all distribution panelboards. Ground connections at panelboards, outlets, equipment, and apparatus shall be made in an approved and permanent manner.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Metal surfaces where grounding connections are to be made shall be clean and dry. Steel surfaces shall be ground or filed to remove all scale, rust, grease, and dirt. Copper and galvanized steel shall be cleaned with emery cloth to remove oxide before making connections.

B. Raceways

1. Conduit which enters equipment such as switchgear, motor control centers, transformers, panelboards, variable frequency drives, instrument and control panels, and similar equipment shall be bonded to the ground bus or ground lug, where provided, and as otherwise required by the NEC.

END OF SECTION

SECTION 16190
SUPPORTING DEVICES

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install structural steel supports for mounting and installing all electrical, lighting, alarm systems, instrumentation, and communications equipment furnished under this Contract.

B. Equipment shall be installed strictly in accordance with recommendations of the manufacturer and best practices of the trade resulting in a complete, operable, and safe installation. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation.

C. Reference Section 16000, Basic Electrical Requirements.

1.02 SUBMITFALS

A. In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification section.

1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

2. Complete assembly, layout, installation, and foundation drawings with clearly marked dimensions.

PART 2 - PRODUCTS

2.01 MUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 MATERIALS

A. Materials used iii accordance with this Section shall be as specified herein.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Concrete or Masonry Inserts

1. The Contractor shall be responsible for the furnishing and installation of all conduit sleeves, anchor bolts, masonry inserts, and similar devices required for installation of equipment furnished under this Contract.

2. If a time delay for the arrival of any special inserts or equipment drawings, etc. occurs, the Contractor may, if permitted by the Engineer, make arrangements for providing approved recesses and openings in the concrete or masonry and, upon subsequent installation, the Contractor shall be responsible for filling in such recesses and openings. Any additional costs that may be incurred by this procedure shall be borne by the Contractor.

3. The Contractor shall furnish leveling steel channels for all switchgear, switchboards, motor control centers, and similar equipment. The leveling steel channels shall be provided for installation in the equipment supporting pads. Coordination of the installation of these channels with the concrete pad is essential and required. Pad height shall be as required to maintain coverage of the reinforcement bars while not exceeding the maximum mounting heights requirements of the NEC.

B. Support Fastening and Locations

1. All equipment fastenings to columns, steel beams, and trusses shall be by beam clamps or welded. No holes shall be drilled in the steel. Where supports or hangers are required for heavy electrical equipment units exceeding fifty pounds, a registered professional engineer shall check the steel. Where required, additional sections shall be provided for a safe installation. Supports and hangers shall be PVC coated as required and shall be compatible with the balance of the installation.

2. All holes in hung ceilings for support rods, conduits, and other equipment shall be made adjacent to bars where possible, to facilitate removal of ceiling panels.

3. The support system shall be made of Type 304 stainless steel or PVC coated rigid galvanized steel. The materials of construction shall be coordinated with the process/chemical area in which the support system will be installed.

4. All hardware (bolts, nuts, washers, etc.) shall be Type 304 stainless steel.

5. All supports shall be rigidly bolted together and braced to make a substantial supporting framework. Where possible, control equipment shall be grouped together and mounted on a single framework. Wherever this occurs, a provision shall be made for ready access to the wiring for connections to the equipment by means of boxes with screw covers.

6. Aluminum support members shall not be installed in direct contact with concrete. Stainless steel or non-metallic "spacers" shall be used to prevent contact of aluminum with concrete.

7. Actual designs for supporting framework should take the nature of a picture frame of channels and bracket with a plate for mounting the components. The Contractor is responsible for the design of supporting structure; he shall submit design details to the Engineer for acceptance before proceeding with the fabrication.

8. Wherever dissimilar metals come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

END OF SECTION

SECTION 16195
ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. All electrical equipment shall be properly identified in accordance with these Specifications and the Contract Drawings. All switchgear, switchboards, motor control centers, variable frequency drives, lighting and distribution panelboards, combination starters, control panels, pull junction boxes, enclosures, disconnect switches, control stations, and similar equipment shall be identified in the manner described, or in an equally approved manner.

B. The types of electrical identification specified in this section include, but are not limited to, the following:

1. Exposed conduit color banding.
2. Operational instructions and warnings.
3. Danger signs.
4. Equipment system identification signs.
5. Nameplates.

1.02 SIGNS

A. "DANGER-HIGH-VOLTAGE" signs shall be securely mounted on the entry doors of all electrical rooms.

1.03 LETTERING AND GRAPHICS

A. The Contractor shall coordinate names, abbreviations, and other designations used in the electrical identification work with the corresponding designations shown, specified or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment.

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.

1.05 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The material covered by these Specifications is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

2.02 NAMEPLATES

A. Nameplates shall be engraved, high pressure plastic laminate, black with white lettering.

2.03 HIGH VOLTAGE SIGNS

A. Standard "DANGER" signs shall be of baked enamel finish on 20 gage steel; of standard red, black and white graphics; 14 inches by 10 inches size except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where a larger size is needed for adequate viion.

2.04 CONDUIT MARKERS

A. Conduit markers shall be bronze metal tag 1/2 inch in diameter, with 1/8 inch hole, with copper wire through hole and attached to conduit by twisting ends of wire. Lettering shall indicate conduit numbers.

PART 3 - EXECUTION

3.01 NAMEPLATES

A. Nameplates shall be attached to the equipment enclosures with (2) two stainless steel sheet metal screws for nameplates up to 2-inches wide. For nameplates over 2-inches wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. The utilization of adhesives is not permitted.

3.02 CONDUIT IDENTIFICATION

A. Where electrical conduit is exposed in spaces with exposed mechanical piping which is identified by a color-coded method, apply color-coded identification on the electrical conduit in a manner similar to the piping identification. Except as otherwise indicated, use orange as the coded color for conduit marker backgrounds.

3.03 OPERATIONAL IDENTIFICATION AND WARNINGS

A. Wherever reasonably required to ensure safe and efficient operation and maintenance of the electrical systems and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install plastic signs or similar equivalent identification, instruction,, or warnings on switches, outlets, and other controls, devices, and covers or electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes. Signs shall be attached as specified above for nameplates.

END OF SECTION

SECTION 16440
DISCONNECT SWITCHES

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install separately mounted, individual disconnect switches as specified herein and indicated on the Drawings.

B. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

   a. None required.

2. Field Tests

   a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Spare Parts List

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of disconnect switch.

3. Assembled weight of each unit.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are, being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 TOOLS, SUPPLIES, AND SPARE PARTS

A. The equipment shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment, and with all spare parts as recommended by the equipment manufacturer.

B. One complete set of spare fuses for each ampere rating installed shall be furnished and delivered to the Owner at the time of final inspection.

C. Spare parts lists,' included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Term such as "1 lot of packing material" are not acceptable.

D. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.06 IDENTIFICATION

A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved indicating the circuit number and equipment name with which it is associated. Equipment identification shall be in accordance with Section 16195, Electrical - Identification.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Switches shall be manufactured by Square D Company, Cutler-Hammer, General Electric Company, or equal.

2.02 DISCONNECT SWITCHES

A. Disconnect switches shall be heavy-duty type and/or as specified in these Specifications. Switches shall be furnished and installed as shown on the Drawings and as required by the NEC. Handles shall be lockable.

B. Switches shall be NEMA Type HD, single-throw, externally operated, fused or non-fused as required. Switches of the poles, voltage, and ampere ratings shown shall be furnished in NEMA 1 A (gasketed) enclosures in indoor dry areas, and in NEMA 4X Type 304 stainless steel enclosures for damp/wet indoor process areas. Enclosures for outdoor applications shall be NEMA 4X Type 304 stainless steel.

C. Disconnect switches shall be quick-make, quick-break and with an interlocked cover which cannot be opened when switch is in the "ON" position and capable of being locked in the "OPEN" position.

D. A complete set of fuses for all switches shall be furnished and installed as required. Time-current characteristic curves of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Fuses shall have voltage rating not less than the circuit voltage.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All disconnect switches to be mounted five (5) feet above the floor, at the equipment height where appropriate, or where shown otherwise.

B. The Contractor shall furnish and install fuses of various types as required with the continuous ampere ratings as required or shown on the Drawings.

END OF SECTION

SECTION 16461
DRY TYPE DISTRIBUTION TRANSFORMERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, and test transformers for power and lighting distribution systems as specified herein, as indicated on the Drawings, and as required to complete the electrical installations.

B. All equipment specified in this Section shall be furnished by the transformer manufacturer who shall be responsible for the suitability and compatibility of all included equipment.

C. Reference Section 16000, Basic Electrical Requirements, and Section 09900, Painting.

1.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

    a. None required.

2. Certified Shop Tests

    a. The transformers shall be given routine factory tests in accordance with the requirements of the ANSI and NEMA standards. Temperature rises may be certified from basic design.

    b. As a minimum, the following tests shall be made on all transformers:

        1. Ratio tests on the rated voltage connection and on all tap connections.
        2. Polarity and phase-relation tests on the rated voltage connection.
        3. Applied potential tests.
        4. Induced potential tests.
        5. No-load and excitation current at rated voltage on the rated voltage connection.

3. Field Tests

    a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

    b. After installation, the transformers shall be subjected to routine insulation resistance tests. The tests shall be made by the Contractor who shall also furnish the required testing equipment.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Division 1, the Contractor shall obtain from the •equipment manufacturer and submit the following:

1. Shop Drawings.

2. Operation and Maintenance Manuals.

3. Spare Parts List.

4. Special Tools List.

5. Reports of Certified Shop Tests.

B. Each submittal shall be identified by the applicable specification section

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein, and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

2. Drawings showing clearly marked dimensions and weight for each transformer.

3. Sample equipment nameplate diagram.

D. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings (e.g. T14).

E. The shop thawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.06 TOOLS, SUPPLIES AND SPARE PARTS

A. The transformers shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.

B. Spare parts lists, included with the Shop Drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.07 IDENTIFICATION

A. Each transformer shall be identified with the equipment item number indicated on the Contract Drawings and the accepted Shop Drawings. A nameplate shall be securely affixed in a conspicuous place on each transformer. Nameplates shall be as specified in Section 16195, Electrical - Identification.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Dry type distribution transformers shall be manufactured by Square D Company, General Electric Company, Cutler-Hammer, or equal.

2.02 DRY TYPE TRANSFORMERS

A. Furnish and install single-phase and three-phase general purpose, dry-type transformers, as specified herein and indicated on the Drawings. The transformers shall be 60 Hz, self-cooled, quiet-design insulated of the two winding type.

B. The transformers shall be Underwriters Laboratories, Inc. listed and shall bear the UL label.

C. The primary windings shall be rated 480 VAC for use on 3-phase systems and connected delta unless indicated otherwise on the Drawings. KVA ratings shall be as shown on the Drawings. Furnish transformers with two 2-1/2% primary taps above, and four 24/2% primary taps below rated voltage for transformers 15 EVA and above, and two 2-1/2% primary taps above, and two 2-1/2% primary taps below rated voltage for transformers less than 15 ICVA. All taps shall be full capacity rated.

D. The ratings of the secondary windings shall be as indicated on the Drawings.

E. Transformers shall be designed for continuous operation at rated KVA, 24 hours a day, 365 days a year, with normal life expectancy as defined in IEEE *65* and ANSI C57.96

This performance shall be obtainable without exceeding *150* degrees Celsius average temperature rise by resistance or 180 degrees Celsius hot spot temperature rise in a 40 degrees Celsius maximum ambient and 30 degrees Celsius average ambient. The maximum coil hot spot temperature shall not exceed 220 degrees Celsius. All insulating materials shall be flame retardant and shall not support combustion as defined in ASTM Standard Test Method D 635. All insulating materials shall be in accordance with NEMA ST 20 Standard for a 220 degrees Celsius UL component recognized insulation system.

F. Transformer coils shall be of the continuous wound copper construction and shall be impregnated with nonhygroscopic, thermosetting varnish.

G. Transformers shall have copper windings.

H. All cores are to be constructed of high grade, nonaging, grain-oriented silicon steel with high magnetic permeability and low hysteresis and eddy current loses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be tightly clamped and compressed with structural steel angles. The completed core and coil shall then be bolted to the base by means of vibration-absorbing mounts to minimize sound transmission. There shall be no metal-to-metal contact between the core and coil assembly and the enclosure.

I. The enclosure shall be made of heavy gauge steel and shall be degreased, cleaned, primed, and finished with a baked weather-resistant enamel. See painting requirements specified in this Section.

J. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees Celsius. Transformers shall be furnished with lugs of the size and quantity required and suitable for termination of the field wiring.

K. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable NEMA, IEEE, and ANSI standards.

L. Transformers shall have core and coil assemblies mounted on rubber isolation pads to minimize the sound levels. The transformers shall not exceed the following ANSI sound levels:

0 to 9kVA 40dB
10 to 50kVA 45dB
51 to 150kVA 50dB
151 to 300KVA 55dB
301 to 500KVA 60dB
501 to 700 KVA 62 dB
701 to l000K.VA 64dB
1001 to 1500 KVA 65dB

2.03 PANTING

A. The exteriors of the transformer enclosures shall be painted as follows:

1. Factory painting: Surfaces shall be cleaned carefully and given a priming basic lead chromate. This shall be followed by two coats of an approved paint applied by brushing.

2. Field painting: After delivery and installation, but before transformers are placed in service, all factory-painted surfaces shall be carefully cleaned and all abrasions shall be repaired. All painted surfaces shall then be given one brushed-on coat of paint as specified for the fourth coat of machinery and equipment in Section 09900 - Painting. Color shall be ANSI #61.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The transformers shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer.

B. Conduit routed to and from the transformer shall be arranged for easy removal of the transformer.

END OF SECTION

SECTION 16470
PANELBOARDS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install panelboards of voltage and current ratings as specified herein and indicated on the Drawings. Panelboards shall be furnished with circuit breaker ratings, number of breakers, number of poles and locations conforming to the panelboard schedules on the Drawings.

B. Reference Section 16000, Basic Electrical Requirements.

1.02 STANDARDS

A. Panelboards shall conform to all applicable Federal, UL, and NEMA standards. Materials and components shall be new and conform to grades, qualifies and standards as specified herein and shown on the Drawings.

B. Panelboards shall comply with the following industry standards:

1. UL Listing/Approval

2. UL Standards

   a. Panelboards - UL 67
   b. Cabinets and Boxes - UL 50

3. National Electrical Code

4. NEMA Standard – PBI

1.03 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

   a. None required

2. Field Tests

   a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Reports of Certified Shop Tests.

3. Spare Parts List.

4. Operation and Maintenance Manuals.

B. Each submittal shall be identified by the applicable specification section.

1.05 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Material specifications and product data sheets.

2. Complete assembly, layout, and installation drawings with clearly marked dimensions for each panelboard.

3. Complete panelboard schedules indicating circuit designations and connected loads as shown on the Drawings for each panelboard.

D. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings (e.g., LP-1, PP-2, etc.).

1.06 TOOLS, SUPPLIES AND SPARE PARTS

A. The panelboards and accessories shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment. For each panelboard, the Contractor shall furnish to the Owner all spare parts as recommended by the equipment manufacturer including one (1) molded case circuit breaker of each type, size, and rating used except for main circuit breakers.

B. Spare parts lists, included with the shop thawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as '1 lot of packing material" are not acceptable.

C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

1.07 IDENTIFICATION

A. Each panelboard shall be identified with the identification number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each panelboard. Nameplates shall be as specified in Section *16195,* Electrical - Identification.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 CONDUCTORS (MAIN BUS AND BRANCH CONNECTORS)

A. All main bus shall be copper sized in accordance with UL standards to limit the temperature rise on any current carrying part to a maximum of 50 degrees C above a maximum ambient temperature of 40 degrees C.

2.03 POWER DISTRIBUTION PANELBOARDS

A. General

1. The power distribution panelboards shall be of the configuration and rated as specified herein and as shown on the Drawings the panelboards shall be dead-front type with automatic trip-free, non-adjustable, thermal overload branch circuit breakers. Circuit breakers shall be bolt-on molded case type conforming to NEMA Standard AB1. The bus ratings shall be as shown on the Drawings. Panels shall be listed by Underwriter's Laboratories, Inc., and so labeled.

2. Power distribution panelboards shall be fully rated and shall have a short circuit rating of 18,000 amperes symmetrical, minimum. In the event the results of the Contractor's short circuit fault analysis, as accepted by the Engineer, indicate that a higher short circuit rating of the panelboards is required, furnish complete panelboards with that higher rating.

3. Power distribution panelboards shall be Square-D Company equivalent, Cutler-Hammer Pow-R-Line Series, General Electric Company equivalent, or equal.

B. Cabinets

1. An Underwriter's Laboratories, Inc. inspection label shall appear on the interior of the cabinet.

C. Bus Work

1. Main bus bars shall be of ample size so that a current density of not more than 1,000 amperes per square inch of cross section will be attained. This current density shall be based on the application of the full load connected to the panel

plus approximately 25% of the full load for spare capacity. The main bus shall be full capacity as based on the preceding for the entire length of the panel so as to provide hill flexibility of circuit arrangement.

2. Solid neutral bus bars, where required, shall be provided. Ratings shall be in accordance with applicable standards.

3. A separate ground bus shall' be provided with lugs for termination of equipment grounding conductors.

4. Branch bus work shall be rated to match the maximum branch circuit breaker which may be installed in the standard space.

5. All bus shall be tin plated copper.

D. Circuit Breakers

1. Circuit breakers shall be bolt-on, molded-case type conforming to NEMA Standard AB 1. Trip elements of circuit breakers shall be 20A, minimum. Minimum branch circuit breaker shall be 1 OOA frame for 60A and above except where shown otherwise on the Drawings or where a larger frame size is standard for the continuous current rating required. Breakers shall have an interrupting rating of 18,000 amperes symmetrical at 480 VAC, minimum. All breakers shall have quick-make, quick-break, toggle mechanism for manual as well as automatic operation.

E. Directories

1. Approved directories with glass or noncombustible plastic cover, and with typewritten designations of each branch circuit, shall be provided in each panel. The Contractor shall maintain in each panel, during the duration of the Contract, a handwritten directory clearly indicating the circuit breakers in service. This directory shall be updated as work progresses, and final, typewritten directories, as specified above, shall be installed at the end of the project. Designations and circuit locations shall conform to the panelboard schedules on the Drawings, except as otherwise authorized by the Engineer.

2. The Contractor shall provide directories identifying panelboards and indicating the size of the feeder (cable and conduit) serving the panel, circuit numbers, and a description of associated branch circuits including branch circuit trip and connected load for each circuit.

2.04 PANTING

A. All metal surfaces of the panelboard enclosures shall be thoroughly cleaned and given one prime of zinc chromate primer. All interior surfaces shall then be given one shop finishing coat of a lacquer of the nitro-cellulose enamel variety. All exterior surfaces shall be given three coats of the same lacquer. The color of finishing coats shall be light gray ANSI #61. C

B. Prior to final completion of the work, all metal surfaces of the e4uipmnt shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

PART 3 - EXECUTION

3.01 MOUNTING

A. The power distribution panelboards shall be finished and installed as shown on the Drawings and as recommended by the equipment manufacturer.

B. Panelboards shall be set true and plumb in locations as shown on the Drawings. The top of panelboard enclosure shall not exceed six (6) feet above finished floor elevation.

C. Enclosures shall not be fastened to concrete or masonry surfaces with wooden plugs. Appropriate cadmium plated or galvanized steel bolts shall be used with expansion shields or other metallic type concrete insert for mounting on concrete or solid masonry walls. Cadmium plated or galvanized steel toggle bolts shall be used for mounting on concrete block or other hollow masonry walls. Bolt diameter shall be as required considering the size and weight of the completed panelboard and enclosure to provide adequate structural support.

D. The Contractor shall: not use factory furnished knockouts with surface back boxes. The Contractor shall punch or drill required openings during installation and shall equip flush back boxes with manufacturer's standard pattern of knockouts. The Contractor shall equip cabinet doors exceeding 40 inches in height with vertical bolt three point locking mechanism.

E. The Contractor shall install cabinets (and other enclosure products) in plumb with the building construction. Flush enclosures shall be installed so that the trim will rest against the surrounding surface material and around the entire perimeter of the enclosure.

3.02 RUBBER MATS

A. A three feet wide rubber mat shall be furnished and installed on the floor and in front of each panelboard. The mat shall be long enough to cover the MI length of each panelboard. The mat shall be located so as not to obstruct the movement of the panel door. The mat shall be 1/4 inch thick with beveled edges, canvas back, sold type with corrugations running the entire length of the mat. The mat shall be guaranteed extra quality, free from cracks, blow holes, or other defects detrimental to their mechanical or electrical strength. The mat shall meet OSHA requirements and the requirements of ANSI/ASTM D-178 J6-7 for Type 2, Class 2 insulating matting.

END OF SECTION

SECTION 16481
INDIVIDUAL MOTOR CONTROLLERS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install separately mounted, individual motor controllers for 120 volt single phase, and 208 and 480 volt three phase motors as specified herein and indicated on the Drawings. Individual motor controllers specified in this Section include magnetic motor starters, manual motor starters, and reduced voltage solid state starters (RVSS).

B. Reference Section 16000, Basic Electrical Requirements and Section 16902, Electric Controls and Relays.

1.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

   a. None required.

2. Field Tests

   a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Spare Parts List.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of individual motor controller. For RVSS starters, show stub-up area locations on the Drawings.

3. Wiring diagrams for each individual motor controller. One wiring diagram which is typical for an equipment group (e.g. reuse water pump) is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.

4. Bill of material list for each individual motor controller.

5. Nameplate schedule for each individual motor controller.

6. Manufacturer's installation instructions.

7. Time-current curves for each type and size protective device if requested by the Engineer.

8. Approximate total shipping weight of each RVSS.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 TOOLS, SUPPLIES, AND SPARE PARTS

A. The equipment shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.

B. The Contractor shall furnish the following minimum spare parts:

1. One (1) overload relay complete with heater for each type, size, and rating used.

2. One (1) motor circuit protector & motor contactor for each type, size, and rating used.

3. One (1) spare control power transformer for each type and size used.

4. Two (2) spare fuses for each size and type used.

C. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

D. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.06 IDENTIFICATION

A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved indicating the circuit number and equipment name with which it is associated. Equipment identification shall be in accordance with Section 16195, Electrical - Identification.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Individual motor controllers specified in this section shall be as manufactured by Square D Company, Cutler- Hammer, General Electric Company, or equal.

2.02 INDIVIDUAL MAGNETIC MOTOR STARTERS

A. Individual magnetic motor starters shall be combination type complete with motor circuit protectors (MCP's). Starters shall be rated 480 VAC, 3-pole, sized for the intended load unless otherwise indicated. In no case shall a starter smaller than a NEMA Size 1 be used. Each starter shall be furnished with a minimum of two spare auxiliary contacts.

B. Provide starters in NEMA 1A (gasketed) enclosures when located in clean, dry, conditioned spaces only. NEMA 1A (gasketed) enclosures shall be finished with corrosion resistant epoxy or acrylic paint. Starters to be furnished and installed in indoor damp or wet areas shall be in NEMA 4X Type 304 stainless steel enclosures. Starters to be provided in all outdoor locations shall be in NEMA 4X Type 304 stainless steel enclosures. Individual motor starters located in hazardous areas shall be suitable for the Class, Division, and Group to suit the application.

C. Furnish and install manual reset overload relays in each phase sized in accordance with the NEC. Provide cover mounted overload reset button with metal (not plastic) shaft and pilot devices as indicated and requited. Starters shall be provided with all coils and controls for 120 VAC operation, unless otherwise indicated on the Drawings.

D. A control power transformer shall be furnished and installed for each motor controller. The minimum control power transformer VA requirements are as follows:

Size 1 75 VA

Size 2 75 VA
Size3 200VA
Size 4 300 VA
Size 5 500 VA

Additional transformer capacity shall be provided when required. The motor controller manufacturer is advised to review the total Contract Documents for additional requirements for space heaters, power factor correction capacitors, and similar equipment which may not be specified in this Division or shown on the Drawings.

E. Ambient compensated, thermal, bi-metallic type overload relays shall be finished and installed providing Class 20 operation. Overload relays shall be equipped with one additional normally Open (NO) and normally closed (NC) isolated contact for use as specified herein or indicated on the Drawings. Solid state overload relays shall only be furnished and installed if specifically accepted by the Engineer. The Contractor shall furnish and install correctly sized overload heaters based on the rating of the motor installed.

F. Unless otherwise indicated, the pilot devices shall be mounted on the covers of the respective enclosures. Pushbuttons, selector switches, and pilot lights shall be 30.5 mm, heavy-duty, oil tight type with provisions to maintain the NEMA ratings of starter enclosures. Legend plates indicating switch positions shall be provided for each pilot device. Pilot lights shall be LED type.

G. Individual magnetic motor starters shall be Square D Company Class 8539 or 8739, Cutler-Hammer Type AN40 or AN80 using NEMA rated Freedom Series starters and contactors, General Electric Company equivalents, or equal.

2.03 INDIVIDUAL MANUAL MOTOR STARTERS

A. Individual manual motor starters in enclosures as specified above shall be furnished and installed for outdoor and indoor exposed work. Furnish and install manual motor starters in outlet boxes with flush wall plates as required for concealed work.

B. Furnish and install manual motor starters with pilot lights and overload heater elements of correct rating based on motor nameplate data.

C. Manual motor starters shall be equipped with either a push button or toggle operator with reset device or mechanism accessible without opening the enclosure.

D. Individual manual motor starters for motors one (1) horsepower and less shall be Square D Company Type F, Cutler-Hammer/Westinghouse Electric Corporation Type MS, General Electric Company equivalents, or equal.

E. Individual manual motor starters for integral horsepower motors shall be Square D Company Type M or T, Cutler-Hammer Type B 100 or B 101, General Electric Company equivalents, or equal.

2.04 AUXILIARY CONTROL RELAYS

A. Provide auxiliary control relays as required to suit the application and as shown on the Drawings. Control relays shall be as specified in Section 16902 - Electrical Controls and Relays. The number of contacts shall be as shown and as required to suit the application plus two spare normally open (N.O.) and two spare normally closed (N.C.).

2.05 REDUCED VOLTAGE SOLID STATE STARTER

A. The solid-state reduced-voltage starter shall be UL and CSA listed. The solid-state reduced-voltage starter shall be an integrated unit with power SCRs, logic board, paralleling bypass contactor, and electronic overload relay enclosed in a single molded housing. The starter shall meet all applicable requirements of this Section and other sections in this Division.

B. The RVSS shall be suitable for continuous operation at 115% of its continuous ampere rating. To ensure that pump/motor load starting torque requirements are met the Contractor shall furnish the starter of the next higher maximum continuous current rating than otherwise required based on the full load ampere rating of the motor.

C. The RVSS shall be suitable for the following environmental conditions:

1. Operating Temperature: 0-50 degrees C
2. Humidity: 0-95 percent non-condensing.
3. Altitude: up to 3,300 feet.

D. The RVSS shall be suitable for operation on a 48OVAC, 3-phase, 60 Hertz system.

E. The SCR-based power section shall consist of six (6) back-to-back SCRs and shall be rated for a minimum peak inverse voltage rating of 500 volts PIV. Units using Macs or SCR/diode combinations are not acceptable. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt effects.

F. The paralleling run bypass contactor shall energize when the motor reaches full speed and close/open under one (1) times motor current. The paralleling run bypass contactor shall utilize an intelligent coil controller to limit contact bounce and optimize coil voltage during, varying system conditions. The coil shall have a lifetime warranty.

G. The starter shall be provided with electronic overload protection as standard and shall be based on an inverse time-current algorithm. Overload protection shall be capable of being disabled during ramp start for long acceleration loads via a DIP switch setting on the device keypad. Overload protection shall be adjusted via the device keypad and shall have a motor full load ampere adjustment from 30 to 100% of the maximum continuous, ampere rating of the starter. The starter shall have selectable overload class setting of *5*, 10, 20 or 30 via a DIP switch setting oh the device keypad. The starter shall be capable of either an electronic or mechanical reset after a fault. Units using bimetal or eutectic alloy overload relays are not acceptable. Over temperature protection (on heat sink) shall be standard.

H. The starter shall provide protection against improper line-side phase rotation as standard. The starter shall stop the motor load if a line-side phase rotation other than A-B-C exists. This feature may be disabled via a DIP switch on the device keypad.

I. The starter shall provide protection against a phase loss or unbalance condition as standard. The starter shall stop the motor load if a 50% current differential between any two phases is encountered. This feature may be disabled via a DIP switch on the device keypad.

J. The starter shall provide protection against a motor stall condition as standard. This feature may be disabled via a DIP switch on the device keypad.

K. The starter shall provide protection against a motor jam condition as standard. This feature may be disabled via a DIP switch on the device keypad.

L. The starter shall be provided with a form C normally open (NO), normally closed (NC) contact that shall change state when a fault condition exists. The contacts shall be rated 60 VA (resistive load) and 20 VA (inductive load). In addition, an LED display on the device keypad shall indicate the type of fault (Overtemp, Phase Loss, Jam, Stall, Phase Reversal, and Overload).

M. The starter shall be provided with an unpowered internal "Run" contact rated for 24VDC or 120 VAC operation.

N. The following control function adjustments on the device keypad shall be provided:

1. Selectable Torque Ramp Start or Current Limit Start
2. Adjustable Kick Start Time, 0-2 seconds
3. Adjustable Kick Start torque, 0-90%
4. Adjustable Ramp Start Time; 0.5-180 seconds
5. Adjustable Initial Starting Ramp Torque; 0-100%
6. Adjustable Smooth Stop Ramp Time; 0-60 seconds.

O. Enclosed units shall include a [motor circuit protector (MCP)] [thermal-magnetic circuit breaker] for short-circuit protection and quick disconnect means. The unit shall include a 24 VDC power supply to be used as the primary control voltage source. An additional 120 VAC control power transformer, fused on both the primary and secondary sides, shall be provided as an additional control power source to power such devices as motor space heaters, solenoid valves, and similar control elements. Input and output isolation contactors shall be furnished as indicated on the Drawings.

P. Unless otherwise specified or indicated on the Drawings, the RVSS enclosure shall be NEMA 12, force ventilated, dead-front, with front accessibility. The enclosure shall be designed for both bottom and top entry. The enclosure shall be designed so rear access is not required for operations, maintenance, and repair tasks. The doors shall have full length piano type hinges and shall be braced to prevent sag when fully open. Other enclosure requirements are:

1. Treat metal surfaces and structural parts by phosphatizing prior to painting.

2. Apply a gun-metal gray undercoat to enclosures which is equal to zinc chromate.

3. Finish exterior of the enclosures in ANSI-61 gray enamel or furnish in a color to match the complete line-up of equipment as indicated on the Drawings and accepted by the Engineer. The Contractor shall reference the Drawings for maximum dimensions of the RVSS's.

Q. The complete starter assembly shall be rated for UL 508D for a withstand rating of 65 kAIC RMS. Starters enclosed in motor control centers shall be of the same manufacturer.

R. The following accessories and spare parts shall be provided for each starter:

1. Surge suppressor mounted on the line side of the starter to clip the input line voltage.

2. Lug kits for both the line and load side of the starter.

3. One (1) user's manual for each frame size of starter.

4. One (1) spare 24VDC power supply for each size used.

S. The reduced voltage solid state starter shall be Type S801 Intelligent Technologies soft starter as manufactured by Cutler-Hammer, General Electric Company equivalent, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All individual motor starters shall be installed as indicated on the Drawings and as recommended by the equipment manufacturer.

END OF SECTION

SECTION 16482
MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation, the motor control centers as specified herein and indicated on the Drawings.

B. The Contractor shall obtain the motor control centers from one manufacturer who shall also manufacture the enclosure and major equipment components, which includes, but is not limited to, starters, branch circuit breakers, main circuit breaker, power monitoring equipment, and other components of the equipment assembly. Subcontracting of wiring is not acceptable.

C. The motor control center shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.

D. Motor control circuits shall be wired in accordance with the requirements specified herein or indicated on the Drawings. Where not indicated, the control circuits shall be standard three-wire "start-stop" and the Contractor shall furnish wiring accordingly.

E. Reference Section 16000, Basic Electrical Requirements; Section 16195, Electrical Identification; Section 16461 - Dry Type Distribution Transformers; Section 16470, Panelboards.

1.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

   a. The motor control center specified in this Section shall be witness shop tested and inspected in accordance with the equipment manufacturer's standard procedures. The testing and inspection procedures shall demonstrate that the equipment tested conforms to the requirements specified, all other applicable requirements, and shall be approved by the Engineer. At least 10 days notice shall be given the Engineer prior to such tests and inspection dates.

2. Certified Shop Tests and Reports

   a. Submit description of proposed testing methods, procedures, and apparatus. Submit notarized and certified copies of all test reports.

   b. As a minimum, the entire motor control center shall go through a quality inspection before shipment. This inspection shall include, but is not limited to, the following:

c. Physical inspection of the structure and the electrical conductors including bussing, general wiring, and units.
d. General electrical tests including power circuit phasing, control circuit wiring, instrument transformers, meters, ground fault system, and device electrical operation.
e. AC dielectric tests of the power circuits and control circuits.
f. Markings/labels, including instructional type, Underwriters Laboratory (UL), and inspector's stamps.
g. The manufacturer shall use integral quality control checks throughout the manufacturing process to maintain the correctness of the MCC.

3. Field Tests

a. Field tests shall be performed in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITFALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Spare Parts List.

3. Special Tools List.

4. Proposed Testing Methods and Reports of Certified Shop and Field Tests.

5. Operation and Maintenance Manuals.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings for each motor control center shall include but not be limited to:

1. Equipment specifications and product data sheets identifying all materials used and methods of fabrication.

2. Example equipment nameplate data sheet.

3. Approximate total shipping weight of each shipping split.

4. Plan, front, and side view drawings, including overall dimensions of each motor control center. Identify shipping splits and show conduit stub-up area locations on the Drawings.

5. Internal schematic and point-to-point wiring diagrams of each motor control unit including variable frequency drives integrated into the motor control center. One wiring diagram, which is typical for an equipment group, is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.

6. Complete single-line diagrams for each motor control center showing circuit breakers, motor circuit protectors, motor starters, instrument transformers, meters, relays, timers, control devices, dry-type transformers, panelboards, and other equipment comprising the complete assembly. Indicate electrical ratings of equipment and devices on these single-line diagrams. Ratings include starter size and type, circuit breaker frame size and trip rating, transformer ratings, panelboard ratings, motor horsepower, and full load current, and similar information.

7. Bill of material list for each motor control center and each motor control unit.

8. Nameplate schedule for each motor control center.

9. Manufacturer's installation instructions.

10. Time-current curves for each type and size protective device if requested by the Engineer.

11. Detailed drawings showing plan, front, and side views as well as appropriate section views of the pre-engineered power distribution center. Include product data sheets for all appurtenances (e.g. exhaust fan, thermostat, etc.) to be furnished and installed in the center. Drawings shall be of sufficient detail to assure proper installation by the Contractor.

D. The shop thawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each MCC unit of each motor control center. These final drawings shall be plastic laminated and securely placed inside each MCC unit door and included in the O&M manuals.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1

1.06 TOOLS, SUPPLIES ANDSPARE PARTS

A. The motor control center and accessories shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor

B. The Contractor shall furnish the following spare parts for each motor control center:

No.	Required Description
1 set	Fuses of each size provided.
1	Starter coil and complete set of contacts for each size and type of starter provided.
1	Relay of each size and type used.
1	Control power transformer of each size used.
5	Lamps and lenses for indicating lights, each color.
1	Indicating lamp sockets for each type used.
2 sets	Overload relays with heaters for each type, size, and rating used.
2	Pilot devices (e.g. pushbutton, selector switch, etc) complete with contact blocks and legend plates for each type, color, size and rating used.
2	Motor circuit protectors for each type, size, and rating used.
2	Molded case circuit breakers for each type, size, and rating used (except main circuit breakers).

C. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

D. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.

E. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

F. Parts shall be completely identified with a numerical system to facilitate parts control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

1.07 SERVICE OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Contractor's personnel and the Owner's operating personnel in its maintenance and operation as outlined elsewhere in Division 1

and Section 11000, Equipment - General Provisions. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One trip of three (3) working days during installation of the equipment for the MCC.

2. One trip of one (1) working day after acceptance of the equipment.

3. One trip of one (1) working day during the warranty period.

4. One trip of one (1) working day for training Owner personnel on the maintenance and operation of the MCC.

B. My additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Field Representative on each day he is at the project.

1.08 IDENTIFICATION

A. Each motor control center shall be identified with the identification number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each motor control center. Nameplates shall be as specified in Section 16195, Electrical – Identification.

1.09 TRAINING

A. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory trained specialists who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section. Training shall be in accordance with the requirements of Section 11000, Equipment-General Provisions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. It is the intent of these specifications that all components of the motor control center are provided by one manufacturer who shall have the sole responsibility of matching all components and providing equipment which functions together as a system.

C. Motor control centers shall be Model 6 as manufactured by Square D Company, Freedom 2100 as manufactured by Cutler-Hammer/Westinghouse Electric Corporation using NEMA rated Freedom Series contactors and starters, General Electric Company 8000-Line, or equal.

2.02 MOTOR CONTROL CENTER

A. General

1. The motor control centers shall be 600 VAC class suitable for operation on a three-phase, 60 Hz system. The motor control centers and their components shall conform to the requirements of applicable standards of NEMA Part ICS 2-322 and Underwriters' Laboratories, Inc. UL-845. Wiring shall be NEMA Class II, Type B. Each vertical section shall be a NEMA 12 unless otherwise specified or indicated on the Drawings.

2. The motor control centers shall be capable of withstanding the fault current available at its line terminals as determined by the Contractor's short circuit study. Minimum bus bracing, withstand, and interrupting ratings are specified herein.

3. Unless otherwise specified or indicated on the Drawings, each vertical section shall be approximately 20 inches wide, and 90 inches high, 20 inches deep, and shall not contain more than six NEMA Size 1 starters.

4. Continuous horizontal wiring troughs shall be provided at both the top and bottom of each section. These troughs shall line up to form a continuous wireway for the full length of the MCC. Each section shall be provided with a large, continuous, full height vertical wiring trough in the right side of each section. Each vertical wiring trough shall be furnished complete with tie bars for conductor support.

5. Each combination motor controller unit shall be equipped with an individual, fused, control power transformer of sufficient capacity to power all connected devices.

6. All control wiring shall be No. 14 AWG (minimum) labeled at each end in accordance with the wiring numbers shown on the accepted shop drawings. Power wiring shall be sized to suit the maximum horsepower rating of unit; No. 12 AWG (minimum). Wiring shall be type TEW rated for 105°C. Wire (color coding shall be as specified in Section 16195, Electrical-Identification, of these Specifications. Wire numbers shall not be repeated in a motor control center.

7. Starter units shall contain the number of auxiliary contacts, unit-mounted pilot devices and indicating lights, control relays, elapsed time meters, and other devices as shown on the Drawings and required for the applications. A minimum of two (2) normally open (NO) and two (2) normally closed (NC) spare contacts shall be provided for each magnetic starter. These spare contacts shall be shown on the submittal Wiring diagrams.

8. Motor control centers shall be furnished with anchor bolts as required for aligning and mounting. Floor channels with end covers shall be of type recommended by the manufacturer and shall be furnished for installation in a concrete pad.

9. The motor control centers, shall be furnished with warning signs to notify maintenance personnel of multiple sources of power within the motor control units. Reference Article 430-74 of the NEC.

B. Power

1. The motor control centers shall be supplied from a 480V, 3-phase, 3 wire, 60 Hz power source. The incoming power feeders shall be sized as shown on the Drawings. All terminals for incoming and outgoing power cables shall be provided with compression lugs, solderless connectors.

C. Bus

1. Power shall be distributed by means of: a continuous, tin plated copper horizontal bus, rated as shown on the Drawings. The bus shall be braced for 65,000A RMS symmetrical at 480V. The horizontal bus shall be effectively isolated from all wiring troughs and other working areas. Vertical bus extensions shall be tin plated copper, isolated by rigid, glass-polyester moldings so as to be a separate self-supported assembly. Silver plated vertical bus may be provided if specifically accepted by the Engineer. Full height vertical bus shall be installed in all sections including 'those containing spare units and "prepared" spaces. No extra safety jacks or similar devices shall be required to obtain an essentially dead-front condition. Access shall be provided for inspection and maintenance from the front. Minimum horizontal bus rating shall be 800A Minimum vertical bus rating shall be 300A

D. Incoming Line Units: Each incoming line unit shall contain buswork and fittings as required with cable lugs for cables of sizes and quantities shown on the Drawings. Cable lugs shall be suitable for their respective conductors.

E. The Unit Compartments:

1. Each unit compartment shall be provided with an individual front door hinged to the vertical structure. Each plug-in unit shall be supported and guided by a removable unit support pan, so that the unit rearrangement is easily accomplished. The rearrangement of the unit support pan from one location to the other shall be accomplished without use of tools. After insertion, each plug-in unit shall be held in place by at least two multi-turn latches, located at the front of the unit. At least one latch shall be located at the top of the insert and one at the bottom, for front accessibility and installation convenience.

2. The unit plug in power stabs shall be electromagnetically tin plated copper to yield a low resistance connection and designed to tighten during heavy current surges and short circuits. The stab shall be backed by spring steel clips to provide and maintain a high pressure, two point connection to the vertical bus. They shall be free floating and self loading plug-in. Wiring from the unit disconnecting means to the plug-in stab shall be exposed at the rear of the unit. The power cable terminations at the plug-in stab shall be mounted in a two-piece, glass polyester support assembly. This support assembly shall provide a separate isolated pathway for each phase, minimizing the probability of a unit fault condition reaching the power bus system.

3. NEMA Size 1 through Size 5 non-reversing starters shall be plug-in units. Size 1, 2, and 3 shall utilize stab assembly rated 100A. Size 4 shall utilize stab at 225A,

Size 5 starters shall utilize dual stab assemblies rated at 225A each, effective capacity of 450A.

4. An industrial, heavy-duty flange handle mechanism shall be supplied for the control of each disconnecting means. This mechanism shall be engaged with the disconnect device at all times as an integral part of the unit regardless of the unit door position. The operator handles shall have an up-down motion with the down position as off. The ON-OFF condition of the disconnecting means shall be permanently marked on the handle operator. It shall be possible to lock the handle in the "OFF" position with up to three (3) 3/8 inch diameter shackle padlocks and in the "ON" position with one (1) 3/8 inch diameter shackle padlock.

5. The operator handle of all units shall be interlocked with the door units so that the disconnect means cannot be switched unless the door unit is closed. A means shall be provided for purposely defeating the interlock during maintenance or testing. This interlock shall also prevent, opening the unit door unless the disconnecting means is in the off position. An externally operated defeater requiring the use of a screwdriver shall provide access to the unit without interrupting service.

6. The overload relays shall be resettable from the outside of the enclosure by means of an insulated bar or button. Shaft from button to overload relay shall be metal; plastic is not acceptable.

F. Ground Bus

1. The horizontal ground bus shall be tin plated .copper and located in the bottom horizontal wireway. The minimum size of the horizontal ground bus shall be 1/4 inch x 1 inch (6.35mm x 25.4mm).

2. A pressure type ground lug(s) shall be mounted on the ground bus in the incoming line section, size, and quantity as required for the termination of system and equipment grounding conductors.

3. The vertical ground bus shall be tin plated copper and solidly connected to the horizontal ground bus. This ground bus, in combination with the unit ground bus stab, establishes unit grounding before the plug-in power stabs engage the power bus, and conversely, as: the unit is withdrawn, grounding is maintained until after the plug-in power stabs are disengaged.

4. The vertical load ground bus shall be tin plated copper and solidly connected to the horizontal ground bus. The vertical load ground bus assembly, comprised of the vertical load ground bus and the unit load ground bus connector, shall provide a termination point for the load equipment grounding conductor at the unit. This fixed connection shall not have to be removed when the unit is withdrawn *from* the motor control center.

G. Isolation and Insulation

1. Horizontal bus access covers and vertical bus covers shall isolate the energized buses to guard against the hazard of accidental contact. These covers shall be molded of a glass polyester material.

2. The horizontal bus shall be isolated from the top horizontal wireway by a grounded steel barrier. This barrier shall be removable to allow access to the bus and connections for maintenance.

3. The vertical bus cover shall provide unit plug-in openings which shall permit unit plug-in stab assemblies to pass through and engage the vertical bus. The unit plug-in openings shall be sized to minimize the probability of inadvertent contact with the vertical bus.

4. Isolation of unused stab openings shall be accomplished by use of a manual shutter to close off the stab opening. These shutters shall be attached to the structure so that when they are removed (to allow a stab connection) they are retained in the structure and are readily accessible for use should a plug-in unit be removed from the motor control center.

5. All units shall be isolated from one another, above and below, by unit support pans or steel barriers, which can remain in place when the units are withdrawn.

6. Incoming line compartments shall be isolated from horizontal and vertical wireways by steel barriers.

7. Unit to vertical wireway isolation shall be available as a molded unit isolating barrier.

H. Combination Motor Control Units

1. Motor branch circuits shall be protected by a motor circuit protector (MCP).

2. The motor circuit protector shall be operated by a toggle type handle and shall have a quick make, quick break overcenter switching mechanism that is mechanically trip free from the handle, so that the contacts cannot be held closed against short circuits and abnormal currents. Tripping shall be clearly indicated by the handle automatically assuming a position midway between the manual ON and OFF positions. All latch surfaces shall be ground and polished. All poles shall be so constructed that they open, close, and trip simultaneously.

3. Motor circuit protectors shall be completely enclosed in a molded case. Motor circuit protectors shall have the trip unit sealed to prevent tampering. Ampere ratings shall be clearly visible. Contacts shall be of non-welding silver alloy. Arc extinction must be accomplished by means of arc chutes, consisting of metal grids mounted in an insulating support.

4. Each pole of these motor circuit protectors shall provide instantaneous short circuit protection by means of an adjustable magnetic only element.

5. Motor circuit protectors shall be applied in circuits with available fault currents not exceeding those listed by the control manufacturer for the motor circuit

protectors in combination with a contactor and overload relay. Motor circuit protectors interrupting capacity shall be a minimum of 65,000A RMS symmetrical at 480V.

6. Motor circuit protectors ratings, modifications, etc., shall be as specified herein and as indicated on the Drawings.

7. Motor circuit protectors shall be completely enclosed molded case devices with a current sensing coil in each of the 3 poles and have an adjustable magnetic trip setting by means of a single knob on the front. The motor circuit protector shall be manually operable. The protector shall be designed to meet the NEC requirement concerning motor full load and locked-rotor current.

8. The settings of the motor circuit protectors shall be based on the Contractor's power studies specified in Section 16000, Basic Electrical Requirements, and the motor nameplate data of the motors installed.

I. Motor Starters.

1. Motor starters shall conform to NEMA Standard IC 1 and shall- be for across-the-line starting, unless otherwise indicated. IEC rated equipment is not acceptable and shall be used as a basis for rejection of the equipment. The size of the starter shall be as required for the particular load. Minimum starter size shall be NEMA Size 1. Size 1 and 2 starters shall be completely drawout type, so that units maybe withdrawn without disconnecting any wiring. Size 3 and 4 full-voltage, non-reversing starters shall be drawout type after disconnecting power leads only. Starters over three-space units high may be boll-on type. A positive guidance system shall be provided to assure proper alignment of wedge-shaped power stabs in deadfront openings in vertical power bus:

2. A suitable control disconnect device(s) to comply with the requirements ofthe NEC shall be provided:

3. Magnetic starters and contactors shall: be electromagnetic vertical or horizontal lift design with double break cadmium oxide silver contacts. Design shall meet or exceed the requirements of UL and NEMA Standards. Coils shall be hot molded construction to protect the coils from mechanical and environmental damage.

4. Each starter shall be able to accommodate a minimum of seven (7) auxiliary contacts in addition to the hold-in contact.

5. Each starter unit shall be supplied with 3 pole, manual reset overload relays, providing Class 20 operation. These relays shall be the ambient compensated thermal bi-metallic type. The overload relay shall be supplied with an auxiliary contact which is operated when a tripped condition has occurred. Overload relays shall be equipped with one additional normally open (NO) and one additional normally closed (NC) isolated contact for use as specified herein and indicated on the Drawings. These contacts shall be shown on the submittal wiring diagrams. Solid state overload relays shall be furnished and installed only if specifically accepted by the Engineer.

6. Each motor starter coil shall be equipped with a surge-suppression device for protection of the solid state equipment (e.g. programmable logic controller) wired as part of the control circuit.

7. If required, Interposing relays with 120 VAC coils shall be furnished for the motor control circuits as specified herein, indicated on the Drawings, and as required. The contact ratings of the relays shall be coordinated with the burden of the motor starter coil. If the burden or other electrical requirements exceed the contact rating of general purpose, plug-in relays, machine tool type relays with adequate contact ratings shall be provided.

8. The minimum control power transformer VA requirements are as follows:

   a. Size 1 75 VA
   b. Size 2 75VA
   c. Size 3 200 VA
   d. Size 4 250 VA
   e. Size 5 350 VA

9. Additional transformer capacity shall be provided when required. The Contractor and motor control center manufacturer is advised to review the Contract Documents for additional requirements for space heaters, power factor correction capacitors, and similar equipment which may not be specified in this Division or shown on the Drawings.

J. Circuit Breakers

1. Where specified herein, indicated on the Drawings, or required, the main circuit breaker shall be rated for service entrance and bear service entrance label.

2. Unless otherwise indicated, circuit breakers shall be manually operable and shall provide thermal-magnetic, inverse-time-limit overload, and instantaneous, short-circuit protection.

3. Breakers shall be molded case type, rated 480 VAC, 2 or 3 pole and have 100 ampere or larger frames. The minimum interrupting rating shall be 65,000A RMS symmetrical at 480V.

4. Overload protection shall be provided on all poles with trip settings as indicated on the Drawings. Breakers of 225-ampere frames and larger shall have interchangeable trip units and adjustable magnetic trip elements.

5. Time-current characteristic curves and other necessary information and data for each size of breaker furnished shall be provided in the Submittal, if requested by the Engineer.

6. Shunt trip devices shall be provided to trip a circuit from a remote location by means of a trip coil energized from a separate circuit. A 120V shunt trip shall be capable of operating *55%* or more of rated voltage. All other shunt trips shall be capable of operating at 75% or more of rated voltage.

K. Terminal Blocks

1. Terminal blocks shall be mounted within the unit insert and in the front for accessibility. Control terminal blocks shall be pull-apart style; Type K - NEMA terminal block as manufactured by Square D Company, Buchanan equivalent, General Electric Company equivalent, or equal.

2. The pull-apart terminal block assembly shall consist of a male and female component held together with captive screws. The terminal block assembly shall be designed to withstand the effects of vibration, yet able to be pulled apart without difficulty. The terminals of the assembly shall be recessed to isolate them from accidental contact. Terminal markings shall be provided for the purpose of identifying terminations.

3. For starters of Size 2 and smaller, terminate starter wiring (power and control) and external field wiring on terminal strips provided in each unit.

4. For starters of Size 3 and larger, terminate control wiring and external field control wiring on the terminal strips. Terminal strips shall be as specified herein and shall be:

   a. Pull-apart type to facilitate wiring connections for disconnecting factory or field conductors.
   b. Rated to accept conductor sizes as specified and as indicated on the Drawings.
   c. Rate terminal strips as disconnecting means for foreign interlock voltages.

5. Provide with a minimum of 25 percent spare terminals.

L. Pushbuttons, Selectors Switches, Pilot Lights, and Other Pilot Devices

1. Pushbuttons and selector switches shall be of the heavy-duty type, 30.5 mm, rated NEMA A600.

2. All pilot devices shall be rated for NEMA Type 12 applications.

3. Pilot lights shall be the LED type.

4. Pilot devices shall be Type K as manufactured by Square D Company, Type 10250T as manufactured by Cutler-Hammer/Westinghouse Electric Corporation, General Electric Company equivalent, or equal.

5. Elapsed time indicators shall be furnished and installed for each starter unit as indicated on the Drawings. Reference Section 16902, Electrical Controls and Relays.

M. Nameplates

1. The motor control centers shall be furnished complete with engraved phenolic nameplates for each MCC and each unit compartment. Equipment names and

numbers shall be coordinated with the Owner as specified in Section 16000. Nameplates shall be as specified in Section 16195, Electrical-Identification.

N. Future Space Requirements

1. Provide spaces for future combination starter and other units in the motor control centers. Furnish spaces with hardware to accommodate future plug-in control unit without modification of vertical sections. Provide the number of spaces required for future control units as indicated on the Drawings, minimum.

2. Provide additional vertical sections to ensure total number of spaces as indicated on the Drawings. The number of vertical sections are contingent upon specific manufacturer's final proposed and Engineer-accepted configuration of MCC units.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The motor control centers shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.

B. Install motor control centers to allow complete unit door swing required for unit removal This is specifically required where a vertical section of MCC is set next to a wall to the left of the MCC section.

C. Where MCC structures are located away from walls to allow bottom conduit entry, the Contractor shall furnish and install sheet metal coverings for openings along the sides and top of the MCC line-up. The purpose of the coverings is to minimize dust, dirt, and undesirable materials from collecting behind the equipment. The sheet metal coverings shall be of the same material, gauge, and finish as the MCC.

3.02 PAINTING

A. All metal surfaces of the motor control centers shall be thoroughly cleaned and given one prime coat of zinc chromate primer. All interior surfaces shall then be given one shop furnished coat of a lacquer of the nitro-cellulose enamel variety. All exterior surfaces shall be given three coats of the same lacquer. The color of the exterior finishing coats shall be ANSI 61 gray. The interior of motor control center shall be painted white.

B. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

3.03 RUBBER MATS

A. A three foot wide rubber mat shall be furnished and installed on the floor and in front of each motor control center. The mat shall be long enough to cover the full length of each motor control center. The mat shall be 1/4 inch thick with beveled edges, canvas back, solid type with corrugations running the entire length of the mat. The mat shall be

guaranteed extra quality, free from cracks, blow holes, or other defects detrimental to their mechanical or electrical strength. The mat shall meet OSHA requirements and the requirements of ANSJ/ASTM D-178 J6-7 for Type 2, Class 2 insulating matting.

END OF SECTION

REV	DESCRIPTION	BY	DATE	-	----	--	--/--/--	-	----	--	--/--/--
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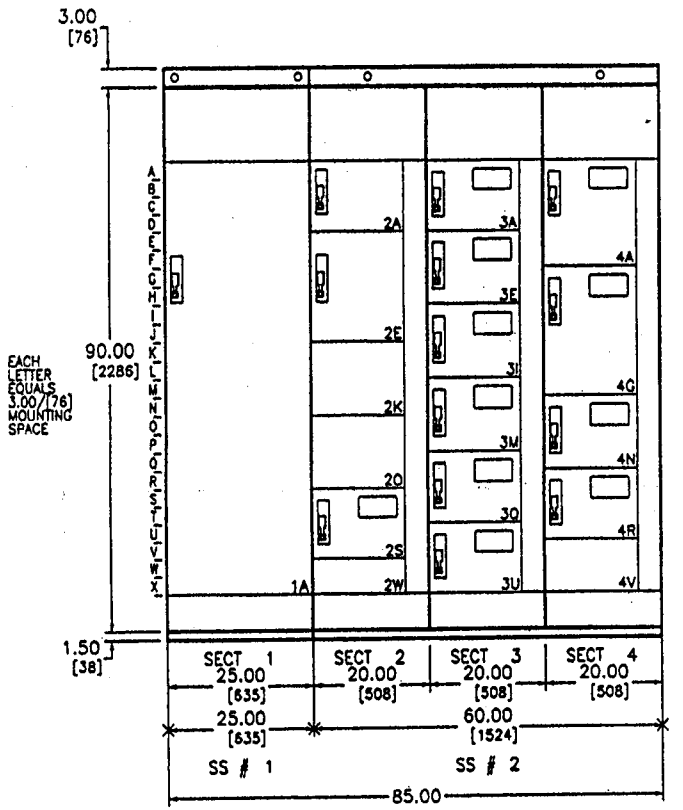

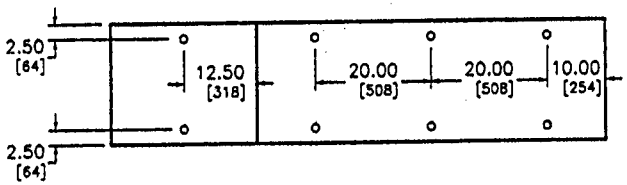

ANCHOR DETAIL

GENERAL NOTES

Class 1 Type B Wiring

PRODUCT DESCRIPTION AND RATINGS

POWER SYSTEM DATA:

480Y/277V 3PH 4W 60Hz
SHORT CIRCUIT RATING: 65kA
POWER ENTERS: Main Breaker Bottom Section 1
CONTROL POWER: 120Vac

BUS SYSTEM DATA:

MAIN HORIZONTAL BUS: 800 Amp Copper/Tin Plated / 1.5"
BUS BRACING: 65kA
VERTICAL BUS: 300 Amp Tin Plated Copper
NEUTRAL BUS: 100 Percent Neutral
HORIZONTAL GROUND BUS: .25" X 1.0" (6.35mm X 25.4mm) Copper
Units Securely Grounded To Structure

ENCLOSURE DATA:

ENCLOSURE TYPE: 20" DEEP Type 1
EXTERIOR COLOR: Electrodeposition Finish ANSI 49 Medium Light Grey
INTERIOR COLOR: Electrodeposition Finish White

STRUCTURE MODIFICATIONS:

Rodent Barriers 1,4
Manual Bus Shutters 2,3,4
Fishtape Barriers 1,2,3,4
Copper Vertical Ground Bus 2,3,4
Neutral Bus Drop 2

EQUIPMENT WEIGHT:

SHIPPING SPLIT # 1: 950.00 Lbs. (430.92 Kg.)
SHIPPING SPLIT # 2: 2250.00 Lbs. (1020.60 Kg.)
TOTAL LINEUP WEIGHT (APPROX): 3200.00 Lbs. (1451.52 Kg.)

PRODUCT ACCESSORIES:

See Unit Features

ENGLISH DIMENSIONS: INCHES

JOB NAME:	TRUCK WASH	EQUIPMENT DESIGNATION:	MCC
JOB LOCATION:	ACUA NJ	EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWN BY:	(Q2C)	DRAWING TYPE:	ELEVATION
ENGR:			SQUARE D Schneider Electric
DATE:	July 09 2008	DWG#	F25471246-01
DRAWING STATUS:	QUOTE	PG 1 OF 2	REV -

REV	DESCRIPTION	BY	DATE
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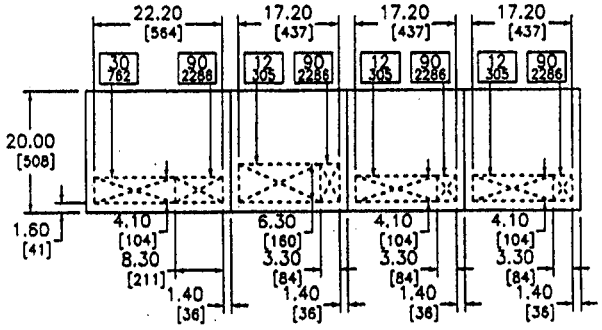
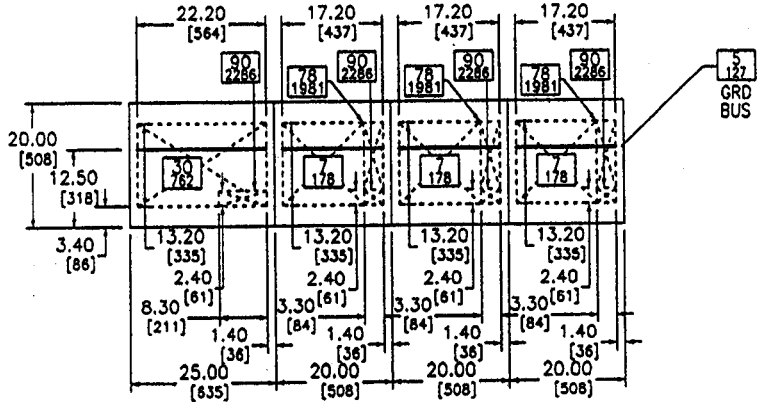


TOP VIEW



FLOOR VIEW

CROSSED AREA REPRESENTS CONDUIT ENTRY AREA. NUMBERS IN BOXES INDICATE VERTICAL CLEARANCE TO NEAREST OBSTRUCTION.

ENGLISH DIMENSIONS: INCHES

JOB NAME:	TRUCK WASH	EQUIPMENT DESIGNATION:	MCC
JOB LOCATION:	ACUA NJ	EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWN BY:	(QZC)	DRAWING TYPE:	ELEVATION
ENGR:			SQUARE D Schneider Electric
DATE:	July 09 2008	DWG# F25471246-01	PG 2 OF 2 REV -
DRAWING STATUS:	QUOTE		

REV	DESCRIPTION	BY	DATE
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UNIT LOC	NAMEPLATE DESIGNATION (GRAY SURFACE/WHITE LETTERS)	UNIT TYPE	SIZE	HP	FRAME AMPS	TRIP AMPS	CONTROL SOURCE	VA	FUSE SIZE PRI	FUSE SIZE SEC	INTERLOCKS NO	INTERLOCKS NC	PILOT DEVICE FEATURES 22 mm- XB5 ON LIGHT	PILOT DEVICE FEATURES 22 mm- XB5 OFF LIGHT	PILOT DEVICE FEATURES 22 mm- XB5 ADDL P/L	PILOT DEVICE FEATURES 22 mm- XB5 SS / PB	OTHER UNIT FEATURES	ELEMENTARY #
1A	MAIN BREAKER	MAIN BKR			MH 1000	800											SOLID NEUTRAL	E25471246--01
2A	LV TRANSFORMER	BRANCH BKR			HJ 150	125												E25471246--02
2E	RECLAIM CONSOLE	BRANCH BKR			JJ 250	200											SOLID NEUTRAL	E25471246--03
2K	PREPARED SPACE	SPACE																
2O	PREPARED SPACE	SPACE																
2S	AIR STRIPPER FAN MOTORS	FVNR	NEMA 2	20	HJ 150	ADJ 50	CONTROL TRANSFORMER	100	.50	1.00	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--04
2W		SPACE																
3A	HYDRAULIC PUMP	FVNR	NEMA 1	10	HJ 150	ADJ 30	CONTROL TRANSFORMER	50	.25	.50	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--05
3E	PRESSURE WASHERS	FVNR	NEMA 1	5	HJ 150	ADJ 30	CONTROL TRANSFORMER	50	.25	.50	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--05
3I	PRESSURE WASHERS	FVNR	NEMA 1	5	HJ 150	ADJ 30	CONTROL TRANSFORMER	50	.25	.50	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--05
3M	EXHAUST FAN - TRUCK WASH	FVNR	NEMA 1	3	HJ 150	ADJ 30	CONTROL TRANSFORMER	50	.25	.50	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--05
3Q	EXHAUST FAN - TRUCK WASH	FVNR	NEMA 1	3	HJ 150	ADJ 30	CONTROL TRANSFORMER	50	.25	.50	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--05
3U	EXHAUST FAN - EQUIPMENT ROOM	FVNR	NEMA 1	5	HJ 150	ADJ 30	CONTROL TRANSFORMER	50	.25	.50	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--05
4A	DETERGENT PUMP	FVNR	NEMA 3	50	HJ 150	ADJ 100	CONTROL TRANSFORMER	150	1.00	1.60	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--06
4G	RINSE PUMP	FVNR	NEMA 4	75	HJ 150	ADJ 150	CONTROL TRANSFORMER	300	1.60	3.20	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--07
4N	EXHAUST FAN - EQUIPMENT ROOM	FVNR	NEMA 1	5	HJ 150	ADJ 30	CONTROL TRANSFORMER	50	.25	.50	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--05
4R	EXHAUST FAN - STORAGE AREA	FVNR	NEMA 1	5	HJ 150	ADJ 30	CONTROL TRANSFORMER	50	.25	.50	1	1	RED			HOA SS	MOTOR CIRCUIT PROTECTOR, MELTING ALLOY O/L	E25471246--05
4V		SPACE																
UNIT LOC	NAMEPLATE DESIGNATION	UNIT TYPE	SIZE	HP	FRAME AMPS	TRIP AMPS	CONTROL SOURCE	VA	FUSE SIZE PRI	FUSE SIZE SEC	INTERLOCKS NO	INTERLOCKS NC	PILOT DEVICE FEATURES 22 mm- XB5 ON LIGHT	PILOT DEVICE FEATURES 22 mm- XB5 OFF LIGHT	PILOT DEVICE FEATURES 22 mm- XB5 ADDL P/L	PILOT DEVICE FEATURES 22 mm- XB5 SS / PB	OTHER UNIT FEATURES	ELEMENTARY #

JOB NAME:	TRUCK WASH
JOB LOCATION:	ACUA NJ
DRAWN BY:	(Q2C)
ENGR:	
DATE:	July 09 2008
DRAWING STATUS:	QUOTE

EQUIPMENT DESIGNATION:	MCC
EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWING TYPE:	UNIT INFORMATION
	SQUARE D Schneider Electric
DWG #	25471246-01
PG	1 OF 1
REV	-

REV	DESCRIPTION	BY	DATE
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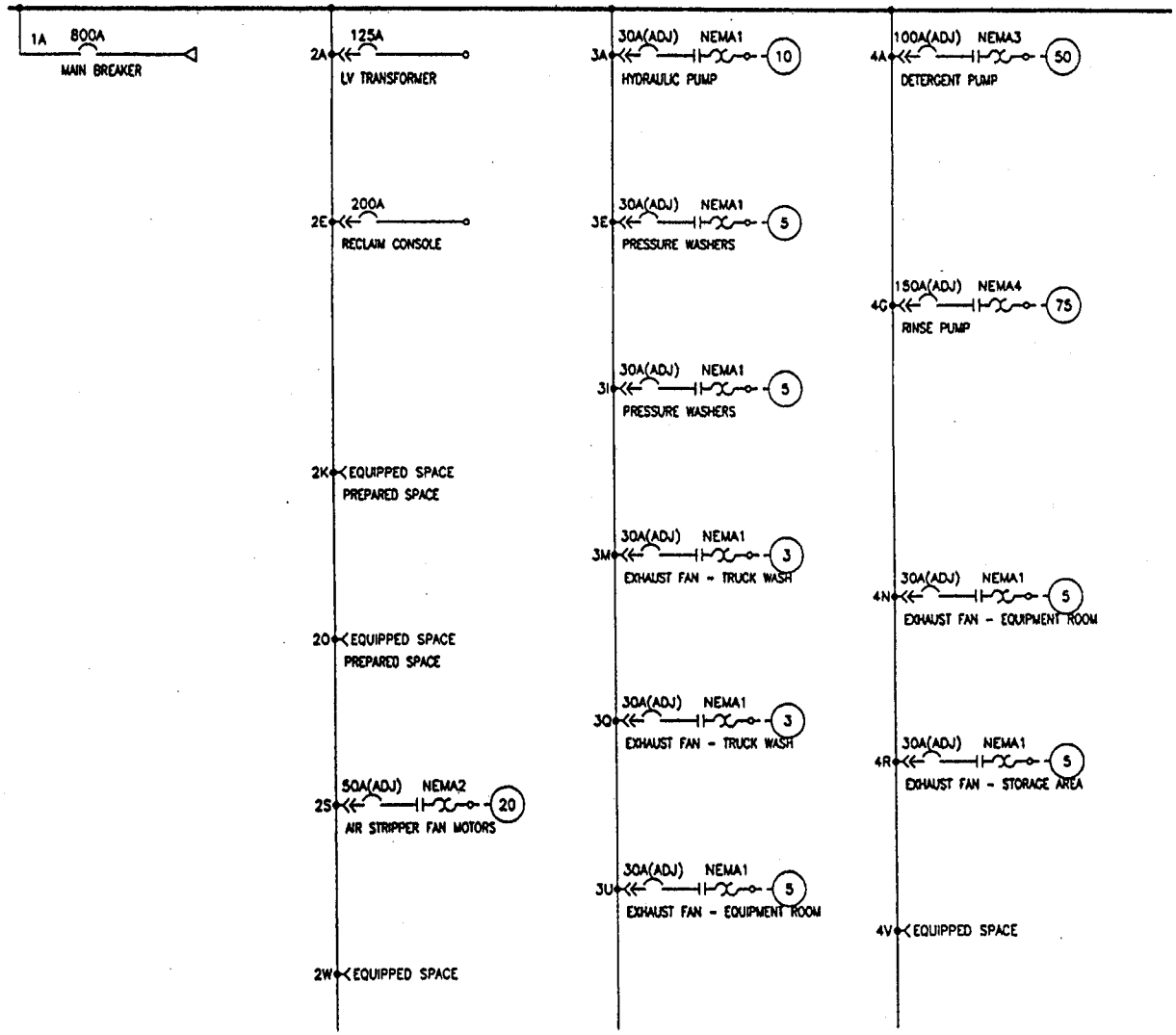

JOB NAME: TRUCK WASH	EQUIPMENT DESIGNATION: MCC
JOB LOCATION: ACUA NJ	EQUIPMENT TYPE: MODEL 6 MOTOR CONTROL CENTER
DRAWN BY: (02C)	DRAWING TYPE: ONE LINE DIAGRAM
ENGR:	SQUARE D Schneider Electric
DATE: July 09 2008	DWG# 025471246-01 PG 1 OF 1 REV -
DRAWING STATUS: QUOTE	

REV	DESCRIPTION	BY	DATE	-	----	--	--/--/--
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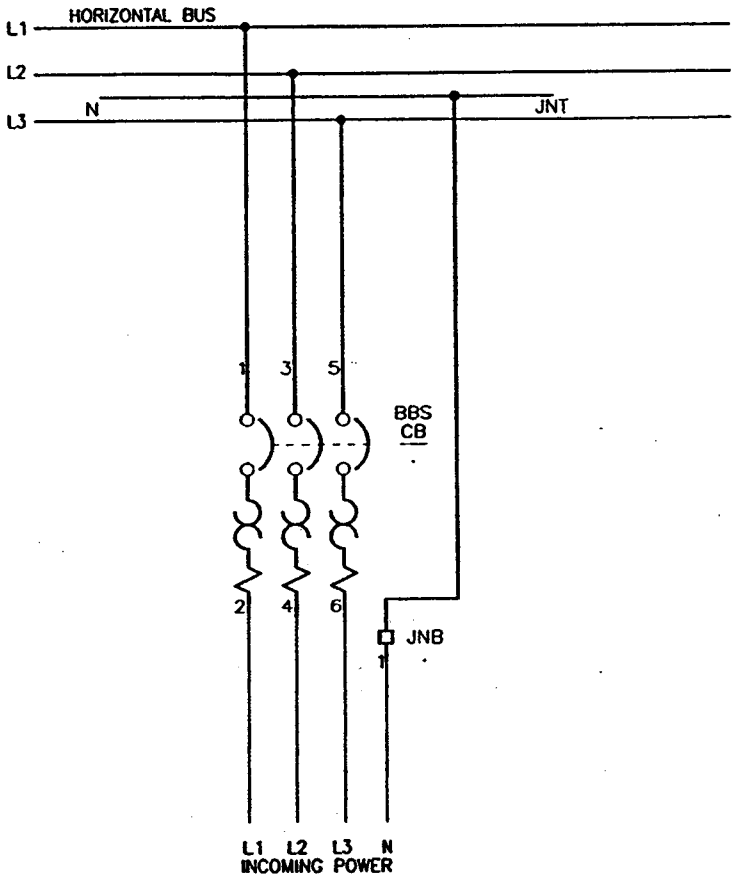

JOB NAME:	TRUCK WASH	EQUIPMENT DESIGNATION:	MCC
JOB LOCATION:	ACUA NJ	EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWN BY:	(Q2C)	DRAWING TYPE:	ELEMENTARY
ENGR:			SQUARE D Schneider Electric
DATE:	July 09 2008		
DRAWING STATUS:	QUOTE	DWG# E25471246-01	PG 1 OF 1 REV -

REV	DESCRIPTION	BY	DATE	-	----	--	--/--/--
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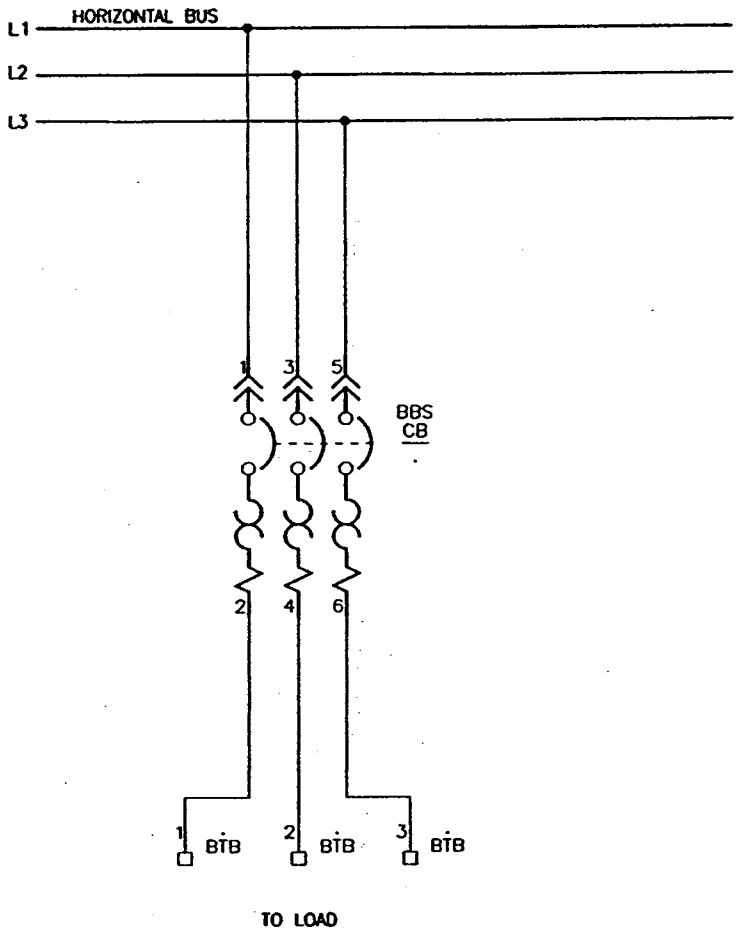

JOB NAME:	TRUCK WASH	EQUIPMENT DESIGNATION:	MCC
JOB LOCATION:	ACUA NJ	EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWN BY:	(Q2C)	DRAWING TYPE:	ELEMENTARY
ENGR:			SQUARE D Schneider Electric
DATE:	July 09 2008		
DRAWING STATUS:	QUOTE	DWG# E25471246-02	PG 1 OF 1 REV -

REV	DESCRIPTION	BY	DATE	-	----	--	--/--/--
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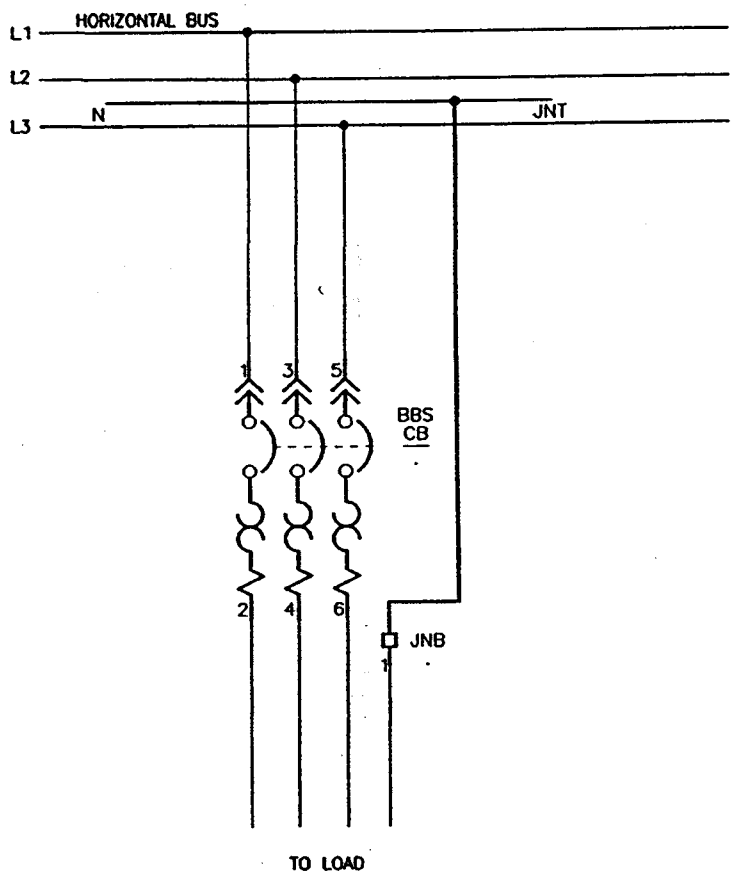

JOB NAME:	TRUCK WASH	EQUIPMENT DESIGNATION:	MCC
JOB LOCATION:	ACUA NJ	EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWN BY:	(Q2C)	DRAWING TYPE:	ELEMENTARY
ENGR:			SQUARE D Schneider Electric
DATE:	July 09 2008		
DRAWING STATUS:	QUOTE	DWG# E25471246-03	PG 1 OF 1 REV -

REV	DESCRIPTION	BY	DATE	-	----	--	--/--/--
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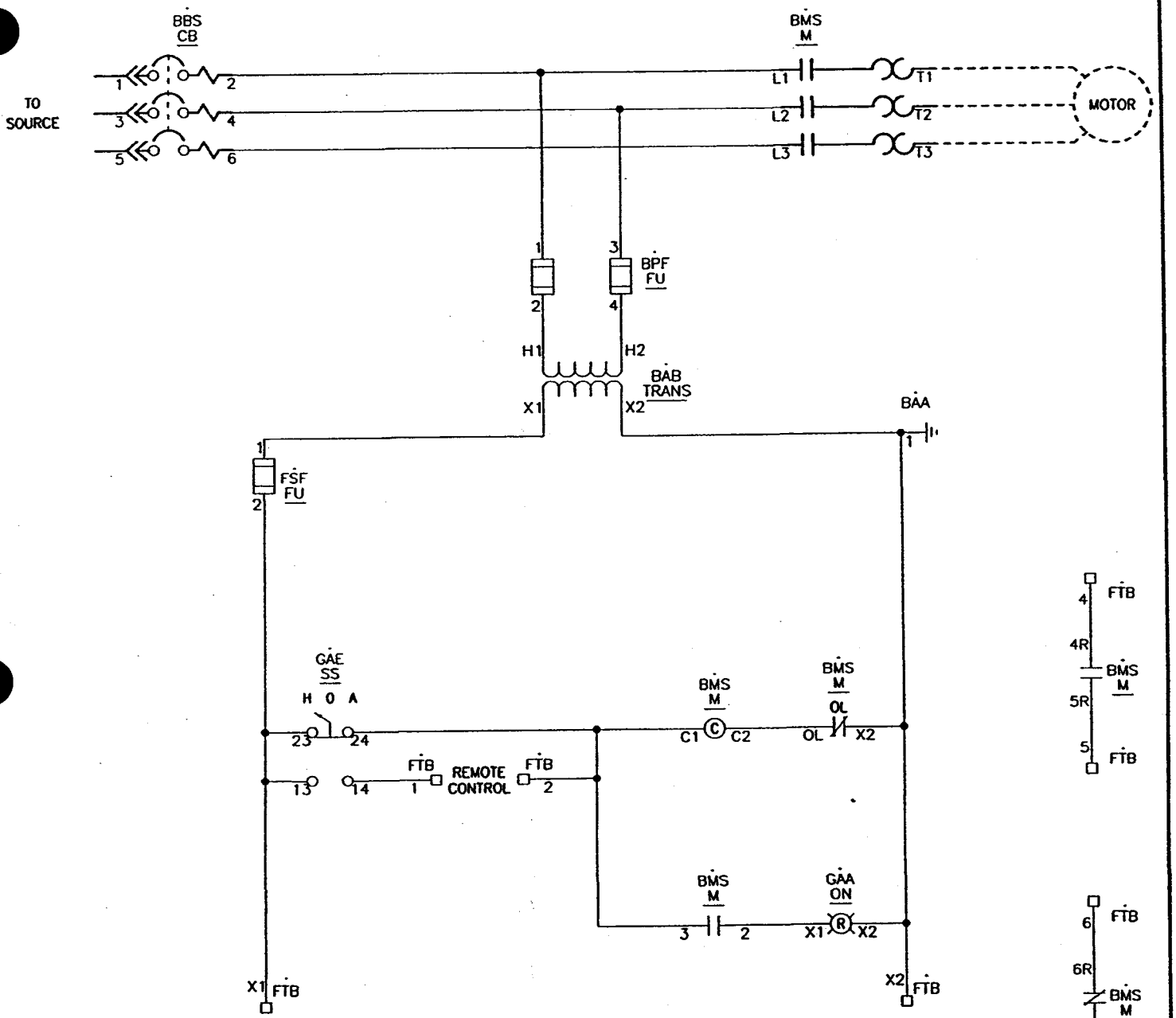

JOB NAME:	TRUCK WASH	EQUIPMENT DESIGNATION:	MCC
JOB LOCATION:	ACUA NJ	EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWN BY:	(Q2C)	DRAWING TYPE:	ELEMENTARY
ENGR:			SQUARE D Schneider Electric
DATE:	July 09 2008		
DRAWING STATUS:	QUOTE	DWG# E25471246-04	PG 1 OF 1 REV -

REV	DESCRIPTION	BY	DATE				
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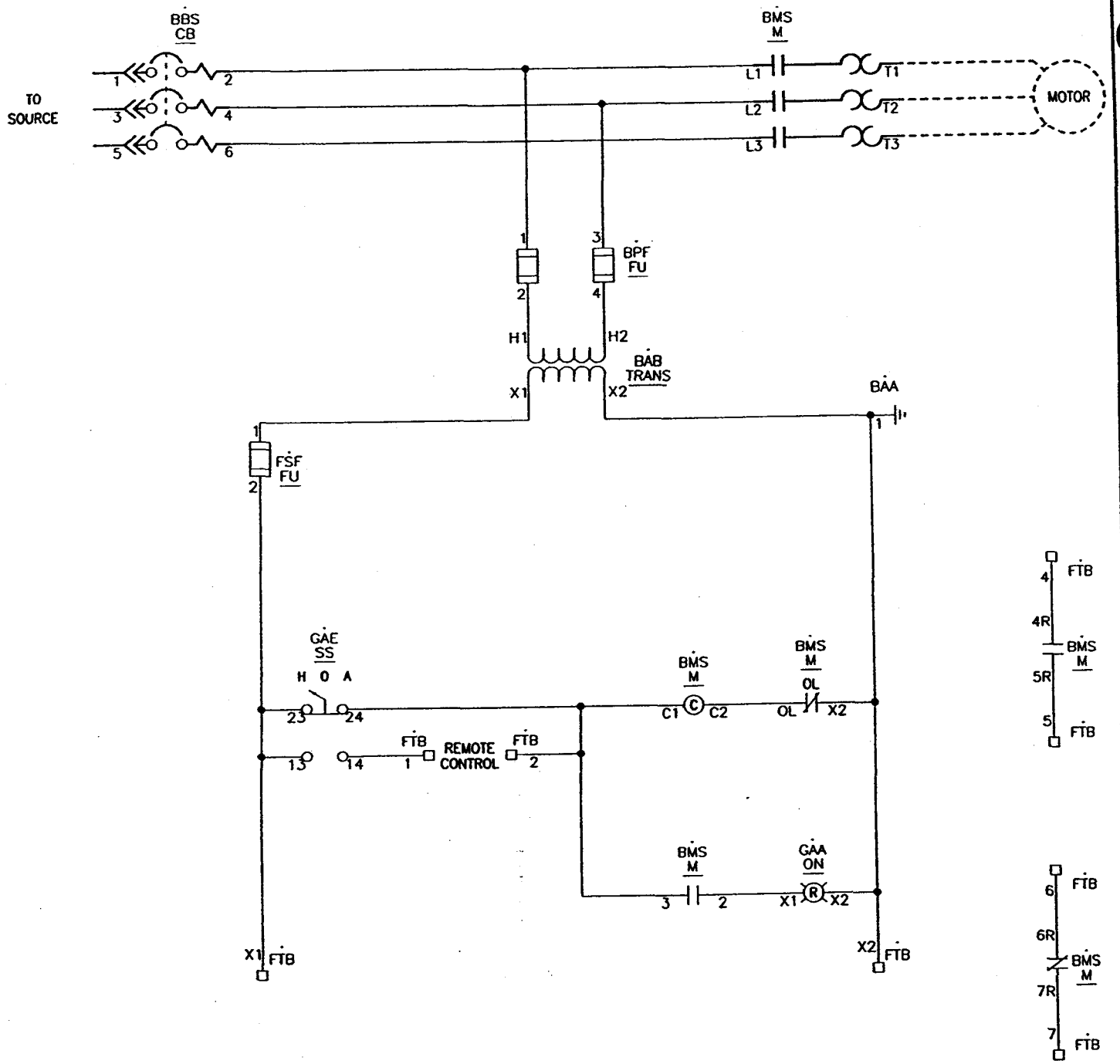

JOB NAME:	TRUCK WASH	EQUIPMENT DESIGNATION:	MCC
JOB LOCATION:	ACUA NJ	EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWN BY:	(Q2C)	DRAWING TYPE:	ELEMENTARY
ENGR:		SQUARE D Schneider Electric	
DATE:	July 09 2008		
DRAWING STATUS:	QUOTE	DWG# E25471246-05	PG 1 OF 1 REV -

REV	DESCRIPTION	BY	DATE				
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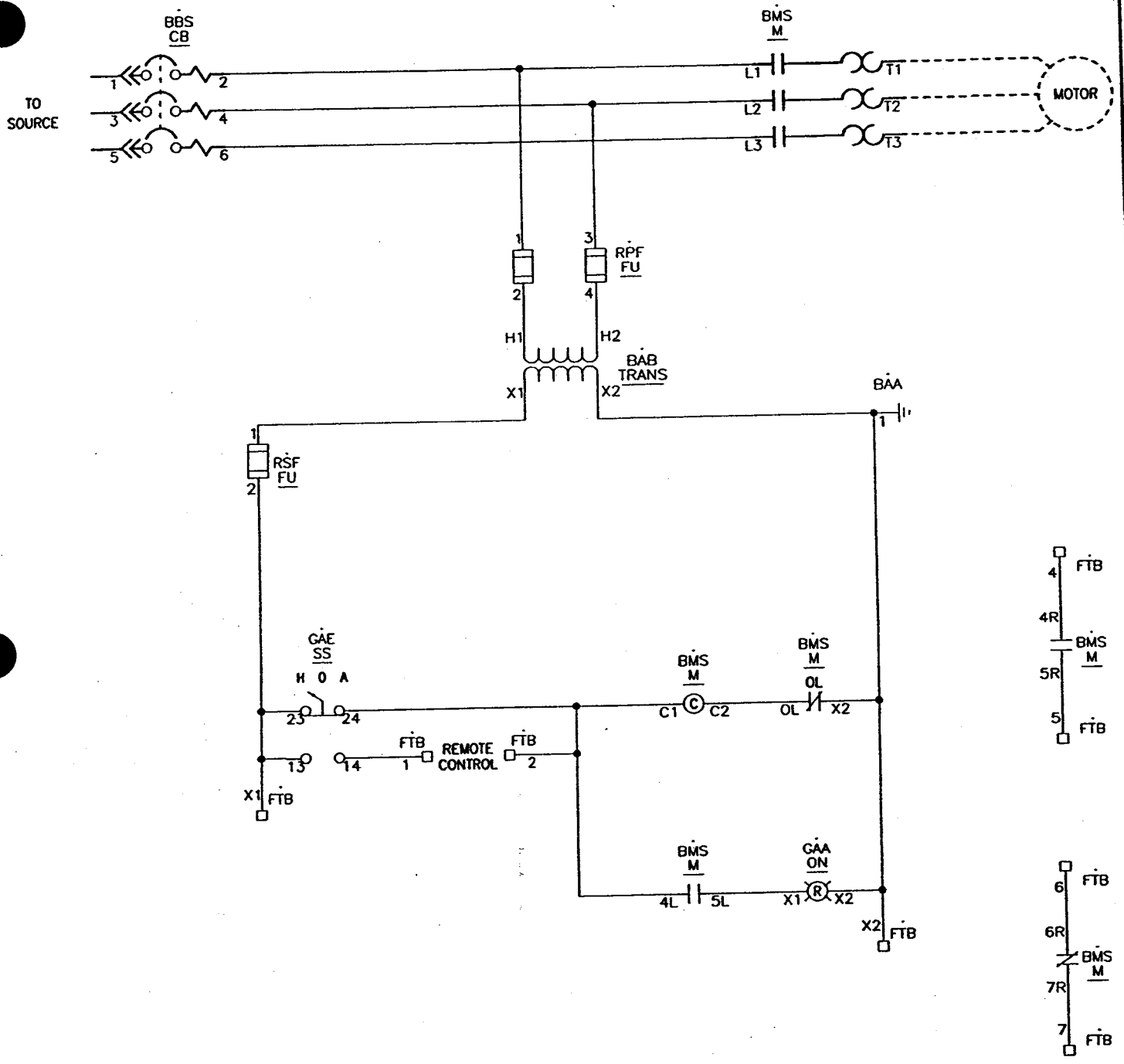

JOB NAME:	TRUCK WASH	EQUIPMENT DESIGNATION:	MCC
JOB LOCATION:	ACUA NJ	EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWN BY:	(Q2C)	DRAWING TYPE:	ELEMENTARY
ENGR:			SQUARE D Schneider Electric
DATE:	July 09 2008	DWG# E25471246-06	PG 1 OF 1 REV -
DRAWING STATUS:	QUOTE		

REV	DESCRIPTION	BY	DATE				
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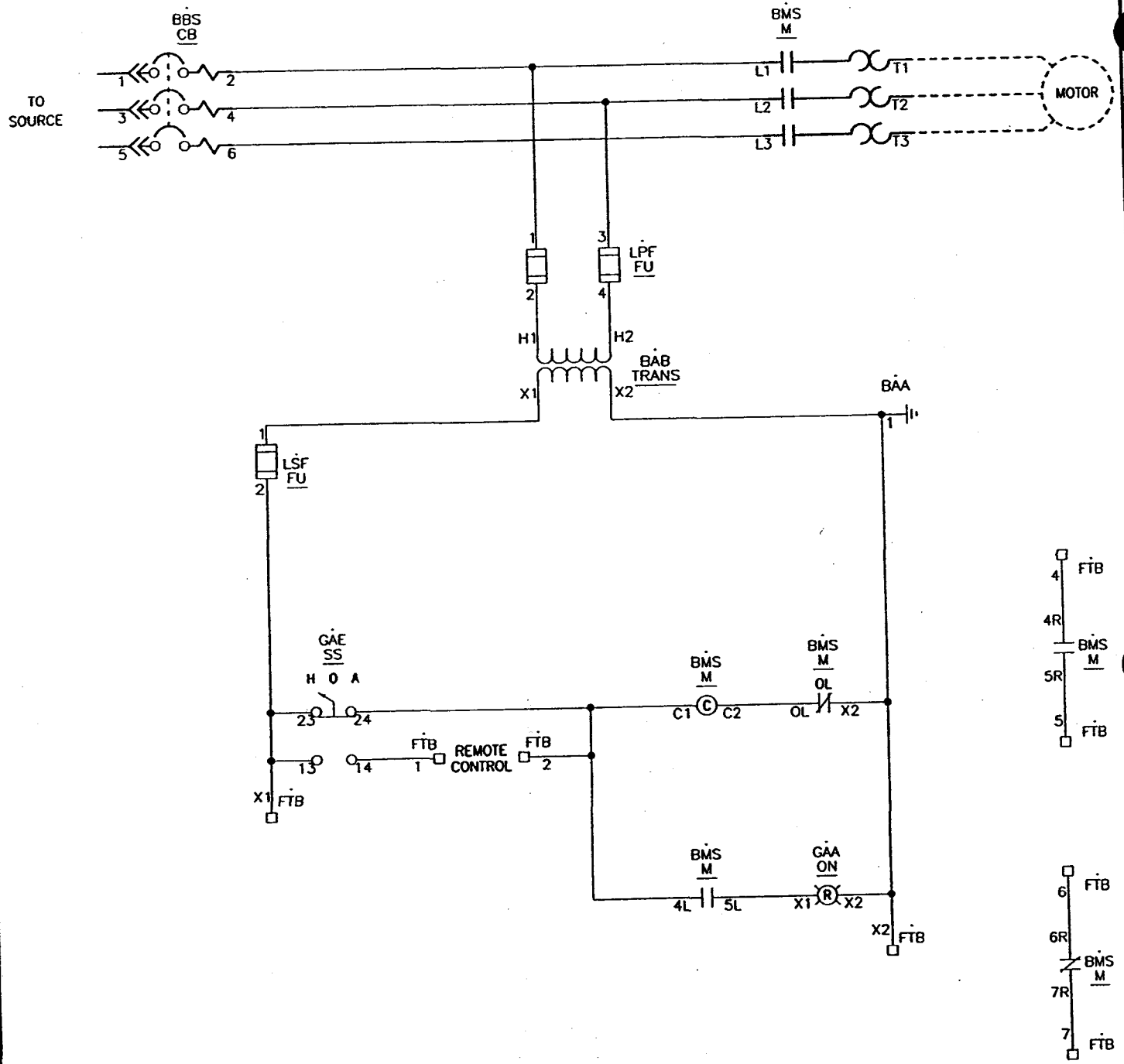

JOB NAME:	TRUCK WASH	EQUIPMENT DESIGNATION:	MCC
JOB LOCATION:	ACUA NJ	EQUIPMENT TYPE:	MODEL 6 MOTOR CONTROL CENTER
DRAWN BY:	(Q2C)	DRAWING TYPE:	ELEMENTARY
ENGR:			SQUARE D Schneider Electric
DATE:	July 09 2008	DWG#	E25471246-07
DRAWING STATUS:	QUOTE	PG 1 OF 1	REV -

REV	DESCRIPTION	BY	DATE				
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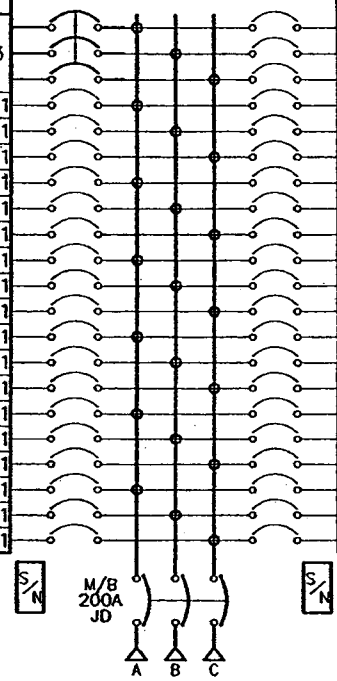
CKT NO	ACCESSORIES	TYPE	RATING AMP/P
1		EDB	20/3
3			
5			
7		EDB	20/1
9		EDB	20/1
11		EDB	20/1
13		EDB	20/1
15		EDB	20/1
17		EDB	20/1
19		EDB	20/1
21		EDB	20/1
23		EDB	20/1
25		EDB	20/1
27		EDB	20/1
29		EDB	20/1
31		EDB	20/1
33		EDB	20/1
35		EDB	20/1
37		EDB	20/1
39		EDB	20/1
41		EDB	20/1

RATING AMP/P	TYPE	ACCESSORIES	CKT NO
20/1	EDB		2
20/1	EDB		4
20/1	EDB		6
20/1	EDB		8
20/1	EDB		10
20/1	EDB		12
20/1	EDB		14
20/1	EDB		16
20/1	EDB		18
20/1	EDB		20
20/1	EDB		22
20/1	EDB		24
20/1	EDB		26
20/1	EDB		28
20/1	EDB		30
20/1	EDB		32
20/1	EDB		34
20/1	EDB		36
20/1	EDB		38
20/1	EDB		40
20/1	EDB		42



PHYSICAL DATA

- o ENCLOSURE: TYPE 1
  SURFACE HINGED FRONT
  FRONT CAT#: NC56SHR
  BOX CAT#: MH56
  DIMENSIONS:
  56"H X 20"W X 5.75"D
  WIRE BENDING SPACE:
  TOP 12.0"
  BOTTOM 12.7"
  SIDE 4.1"
  PBA 553
- o BUSSING: COPPER BUS
  STANDARD PLATING
- o SPECIAL:
  STANDARD SOLID NEUTRAL
  GROUND BAR

ELECTRICAL DATA

- o SYSTEM: 480Y/277 VAC 3PH 4W 60 HZ
  14,000 AMPS SYMS. SCCR
- o MAIN: MAIN BREAKER: JD 200A
  BOTTOM FEED
  18K AIC
  INCOMING CONDUCTOR(S) PER PHASE:
  (1)3/0-350 kcmil (PER NEC)
- o BRANCH MOUNTING TYPE: BOLT-ON

---------- BRANCH SUMMATION ----------

1-20A/3P EDB

39-20A/1P EDB

JOB NAME:	LAKEWOOD TOWNSHIP	EQUIPMENT DESIGNATION:	NF PANEL
JOB LOCATION:	LAKEWOOD NJ	EQUIPMENT TYPE:	NF
DRAWN BY:	(Q2C)	DRAWING TYPE:	ONE LINE DIAGRAM
ENGR:	---		SQUARE D Schneider Electric
DATE:	JUNE 9 2008		
DRAWING STATUS:	QUOTE NOT FOR CONSTRUCTION	DWG# 025471246	PG 1 OF 1 REV 00

REV	DESCRIPTION	BY	DATE				
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CKT NO	ACCESSORIES	TYPE	RATING AMP/P
1		QOB	20/2
3			
5		QOB	20/1
7		QOB	20/1
9		QOB	20/1
11		QOB	20/1
13		QOB	20/1
15		QOB	20/1
17		QOB	20/1
19		QOB	20/1
21		QOB	20/1
23		QOB	20/1
25		QOB	20/1
27		QOB	20/1
29		QOB	20/1
31		QOB	20/1
33		QOB	20/1
35		QOB	20/1
37		QOB	20/1
39		QOB	20/1
41		QOB	20/1

RATING AMP/P	TYPE	ACCESSORIES	CKT NO
20/1	QOB		2
20/1	QOB		4
20/1	QOB		6
20/1	QOB		8
20/1	QOB		10
20/1	QOB		12
20/1	QOB		14
20/1	QOB		16
20/1	QOB		18
20/1	QOB		20
20/1	QOB		22
20/1	QOB		24
20/1	QOB		26
20/1	QOB		28
20/1	QOB		30
20/1	QOB		32
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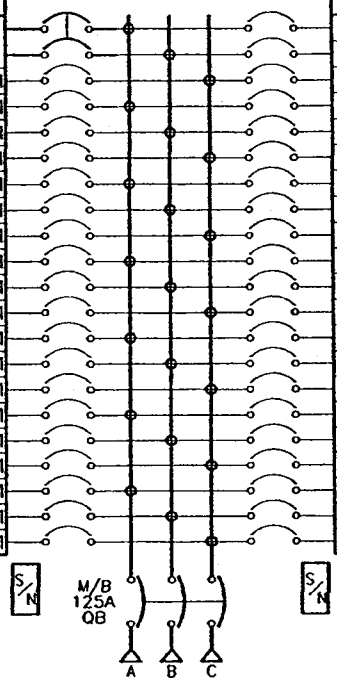


PHYSICAL DATA

o ENCLOSURE: TYPE 1
SURFACE HINGED FRONT
FRONT CAT#: NC50SHR
BOX CAT#: MH50
DIMENSIONS:
50"H X 20"W X 5.75"D
WIRE BENDING SPACE:
TOP 5.0"
BOTTOM 10.4"
SIDE 6.1"
PBA 707HR

o BUSSING: COPPER BUS
STANDARD PLATING

o SPECIAL:
SHIP TOGETHER
STANDARD SOLID NEUTRAL
GROUND BAR

ELECTRICAL DATA

o SYSTEM: 208Y/120 VAC 3PH 4W 60 HZ
10,000 AMPS SYMS. SCCR

o MAIN: MAIN BREAKER: QB 125A
BOTTOM FEED
10K AIC
INCOMING CONDUCTOR(S) PER PHASE:
(1)#4–300 kcmil Al/Cu (PER NEC)

o BRANCH MOUNTING TYPE: BOLT–ON

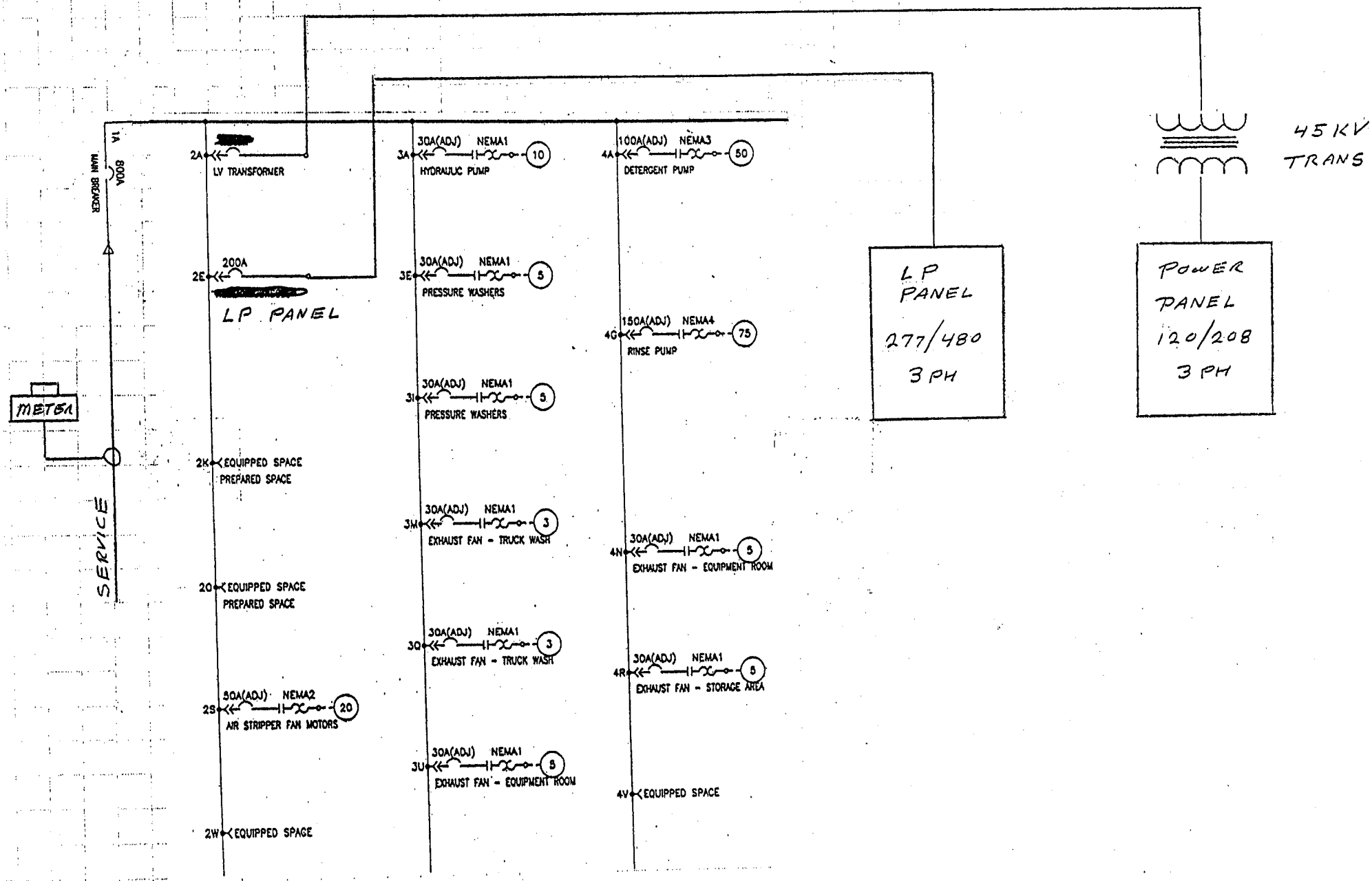
BRANCH SUMMATION

1–20A/2P QOB

40–20A/1P QOB

JOB NAME:	LAKEWOOD TOWNSHIP	EQUIPMENT DESIGNATION:	NQ PANEL
JOB LOCATION:	LAKEWOOD NJ	EQUIPMENT TYPE:	NQ
DRAWN BY:	(Q2C)	DRAWING TYPE:	ONE LINE DIAGRAM
ENGR:	---		SQUARE D Schneider Electric
DATE:	JUNE 9 2008		
DRAWING STATUS:	QUOTE NOT FOR CONSTRUCTION	DWG# 025471246	PG 1 OF 1 REV 00

ONE-LINE ELECTRICAL LAYOUT



LP PANEL SCHEDULE

CKT NO		AMPS	AMPS		CKT NO
1	Emergency lighting	20	20	Outside wall paks	2
3			20	Outside wall paks	4
5					6
7	Lighting, Wash area	20			8
9	Lighting, Equipment area	20			10
11	Lighting, Storage area	20			12
13					14
15					16
17					18
19					20
21					22
23					24
25					26
27					28
29					30
31					32
33					34
35					36
37					38
39					40
41					42

*Add additional breakers when necessary

POWER PANEL SCHEDULE

CKT NO		AMPS	AMPS		CKT NO
1	Kiosk	20	20	Receptacles, Storage area	2
3	Vacuum	20	20	Receptacles, Storage area	4
5	Receptacles, Wash Area	20	20	Receptacles, Equipment area	6
7	Receptacles, Wash Area	20	20	Receptacles, Equipment area	8
9					10
11					12
13					14
15					16
17					18
19					20
21					22
23					24
25					26
27					28
29					30
31					32
33					34
35					36
37					38
39					40
41					42

*Add additional breakers when necessary

SECTION 16511
INTERIOR LIGHTING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.
5. Retrofit kits for fluorescent lighting fixtures.

B. Related Sections include the following:

1. Division 16 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.
2. Division 16 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. BF: Ballast factor.

B. CR1: Color-rendering index.

C. CU: Coefficient of utilization.

D. HID: High-intensity discharge.

E. LER: Luminaire efficacy rating.

F. Luminaire: Complete lighting fixture, including ballast housing if provided.

G. RCR: Room cavity ratio.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.

2. Emergency lighting units including battery and charger.

3. Ballast.

4. Energy-efficiency data.

5. Air and Thermal Performance Data: For air-handling lighting fixtures. Furnish data required in "Submittals" Article in Division 15 Section "Diffusers, Registers, and Grilles."

6. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division IS Section "Diffusers, Registers, and Grilles."

7. Life, output, and energy-efficiency data for lamps.

8. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.

    a. For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by the manufacturer.
    b. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.

1. Wiring Diagrams: Power and control wiring.

C. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Lighting fixtures.

2. Suspended ceiling components.

3. Structural members to which suspension systems for lighting fixtures will be attached.

4. Other items in finished ceiling including the following:

    a. Air outlets and inlets.

b. Speakers.
c. Sprinklers.
d. Smoke and fire detectors.
e. Occupancy sensors.
f. Access panels.

5. Perimeter moldings.

D. Samples for Verification: Interior lighting fixtures designated for sample submission in Interior Lighting Fixture Schedule. Each sample shall include the following:

1. Lamps: Specified units installed.

2. Accessories: Cords and plugs.

E. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.

F. Qualification Data: For agencies providing photometric data for lighting fixtures.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

1. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

D. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections.

1. Obtain Owner's approval of fixtures for mockups before starting installations.

2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire suppression system, and partition assemblies.

1.7 WARRANTY

A. Special Warranty for Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.

2. Warranty Period for Electromagnetic Ballasts: Three years from date of Substantial Completion.

B. Special Warranty for T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, fob the nearest shipping point to Project site, within specified warranty period indicated below.

1. Warranty Period: Two year(s) from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.

2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.

3. Ballasts: I for every 100 of each type and rating installed. Furnish at least one of each type.

4. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2- PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

B. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

3. Basis-of-Design Product: The design for each lighting fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE SB.

E. Metal Parts: Free of burrs and sharp corners and edges.

F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

1. White Surfaces: 85 percent.

2. Specular Surfaces: 83 percent.

3. Diffusing Specular Surfaces: 75 percent.

4. Laminated Silver Metallized Film: 90 percent.

I. Plastic Diffusers, Covers, and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

   a. Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
   b. UV stabilized.

2. Glass: Annealed crystal glass, unless otherwise indicated.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. Electronic Ballasts: Comply with ANSI C82. II instant -start type, unless otherwise indicated, and designed for type and quantity of lamps served. Ballasts shall be designed for full light output unless dimmer or bi-level control is indicated.

   1. Sound Rating: A.

   2. Total Harmonic Distortion Rating: Less than 20 percent.

   3. Transient Voltage Protection: IEEE C62.41, Category A or better.

   4. Operating Frequency: 42 kHz or higher.

   5. Lamp Current Crest Factor: 1.7 or less.

   6. BF: 0.85 or higher.

   7. Power Factor: 0.95 or higher.

   8. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C 82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.

B. Electromagnetic Ballasts: Comply with ANSI C82. I; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.

   1. Ballast Manufacturer Certification: Indicated by label.

C. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.

D. Ballasts for Low-Temperature Environments:

   1. Temperatures Minus 20 Deg F and Higher: Electromagnetic type designed for use with indicated lamp types.

E. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.

   1. Dimming Range: 100 to 5 percent of rated lamp lumens.

2. Ballast Input Watts: Can be reduced to 20 percent of normal.

3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

F. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.

   a. High-Level Operation: 100 percent of rated lamp lumens.
   b. Low-Level Operation: 50 percent of rated lamp lumens.

2. Ballast shall provide equal current to each lamp in each operating mode.

3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

A. Description: Electronic programmed rapid-start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated, Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.

2. Automatic lamp starting after lamp replacement.

3. Sound Rating: A.

4. Total Harmonic Distortion Rating: Less than 20 percent.

5. Transient Voltage Protection: IEEE C62.41, Category A or better.

6. Operating Frequency: 20 kHz or higher.

7. Lamp Current Crest Factor: 1.7 or less.

8. BF: 0.95 or higher, unless otherwise indicated.

9. Power Factor: 0.95 or higher.

10. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

11. Ballast Case Temperature: 75 deg C, maximum.

B. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.

1. Dimming Range: 100 to 5 percent of rated lamp lumens.

2. Ballast Input Watts: Can be reduced to 20 percent of normal.

3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

2.5 BALLASTS FOR HID LAMPS

A. Electromagnetic Ballast for Metal-Halide Lamps: Comply with ANSI.C82.4 and UL 1029. Include the following features, unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.

2. Minimum Starting Temperature: Minus 22 deg F for single-lamp ballasts.

3. Normal Ambient Operating Temperature: 104 deg F.

4. Open-circuit operation that will not reduce average life.

5. Low-Noise Ballasts: Manufacturers standard epoxy-encapsulated models designed to minimize audible fixture noise.

B. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:

1. Lamp end-of-life detection and shutdown circuit.

2. Sound Rating: A.

3. Total Harmonic Distortion Rating: Less than 15 percent.

4. Transient Voltage Protection: IEEE C62.4 1, Category A or better.

5. Lamp Current Crest Factor: 1.5 or less.

6. Power Factor: .90 or higher.

7. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

8. Protection: Class P thermal cutout.

C. Auxiliary Instant-On Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent light output.

2.6 EXIT SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.

2.7 FLUORESCENT LAMPS

A. Low-Mercury Lamps: Comply with EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

B. T8 rapid-start low-mercury lamps, rated 32 W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CR1 75 (minimum), color temperature 3500 K, and average rated life 20,000 hours, unless otherwise indicated.

C. T8 rapid-start low—mercury lamps, rated 17W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CR1 75 (minimum), color temperature 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.

D. Compact Fluorescent Lamps: 4-Pin, low mercury, CR1 80 (minimum), color temperature 3500K, average rated life of 10,000 hours at 3 hours operation per start, and suitable for use with dimming ballasts, unless otherwise indicated.

1. 13W: T4, double or triple tube, rated 900 initial lumens (minimum).

2. 18W: T4, double or triple tube, rated 1200 initial lumens (minimum).

3. 26W: T4, double or triple tube, rated 1800 initial lumens (minimum).

4. 32W: T4, triple tube, rated 2400 initial lumens (minimum).

5. 42W: T4, triple tube, rated 3200 initial lumens (minimum).

6. 55W: T4, triple tube, rated 4300 initial lumens (minimum).

2.8 HID LAMPS

A. Metal-Halide Lamps: ANSI C78. 1372, with a minimum CR1 65, and color temperature 4000 K.

B. Pulse-Start, Metal-Halide Lamps: Minimum CR1 65, and color temperature 4000 K.

C. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CR1 80, and color temperature 4000 K.

2.9 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 16 Section 'Electrical Supports and Seismic Restraints' for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.10 REQUIREMENTS FOR INDIVIDUAL LIGHTING FIXTURES

A. Fixture Types — see lighting fixture schedule

PART 3-EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from lighting fixture corners.

2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.

3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4- inch metal channels spanning and secured to ceiling tees.

4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

C. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.

2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.

3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Adjust aimable lighting fixtures to provide required light intensities.

F. Connect wiring according to Division 16 Section "Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION

SECTION 16521
EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Exterior luminaires with lamps and ballasts.

2. Luminaire-mounted photoelectric relays.

3. Poles and accessories.

B. Related Sections include the following: Division 16 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

C. All relocated light posts will be relocated and replaced with new light posts specified in this section and in the drawings.

1.3 DEFINITIONS

A. CR1: Color-rendering index.

B. HID: High-intensity discharge.

C. Luminaire: Complete lighting fixturc, including ballast housing if provided.

D. Pole: Luminaire support structure.

1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4.

B. Live Load: Single load of 500 lbf, distributed as stated in AASHTO LTS-4.

C. Ice Load: Load of 3 lbf/sq. ft., applied as stated in AASHTO LTS-4.

D. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.

1. Wind speed for calculating wind load for poles 50 feet or less in height is 20 mph.

1.5 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.

2. Details of attaching luminaires and accessories.

3. Details of installation and construction.

4. Luminaire materials.

5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.

   a. For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
   b. Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

6. Photoelectric relays.

7. Ballasts, including energy-efficiency data.

8. Lamps, including life, output, and energy-efficiency data.

9. Materials, dimensions, and finishes of poles.

10. Means of attaching lurninaires to supports, and indication that attachment is suitable for components involved.

11. Anchor bolts for poles.

12. Manufactured pole foundations.

B. Shop Drawings:

1. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

2. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.

3. Wiring Diagrams: Power and control wiring.

C. Samples for Verification: For products designated for sample submission in Exterior Lighting Device Schedule. Each sample shall include lamps and ballasts.

D. Pole and Support Component Certificates Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4 and that load imposed by luminaire has been included in design.

E. Qualification Data: For agencies providing photometric data for lighting fixtures.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with IEEE C2, "National Electrical Safety Code,"

D. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetal lie finishes, handle with web fabric straps.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five years from date of Substantial Completion.

2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.

3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

4. Warranty Period for Lamps: Replace lamps and fuses that fail within 12 months from date of Substantial Completion; furnish replacement lamps and fuses that fail within the second 12 months from date of Substantial Completion.

5. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

B. In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2. Basis of Design Product: The design of each item of exterior luminaire and its support is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 LUMINAIRES, GENERAL REQUIREMENTS

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Comply with IESNA P2-S for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

1. White Surfaces: 85 percent.

2. Specular Surfaces: 83 percent.

3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. Luminaire Finish: Manufacturers standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected from manufacturer's standard catalog of colors.

N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.

3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodie Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodie Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

2.3 LUMINAIRE-MOIJNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with NEMA C136.l0.

2. Adjustable window slide for adjusting on-offset points.

2.4 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features, unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power factor type.

2. Minimum Starting Temperature: Minus 22 deg F.

3. Normal Ambient Operating Temperature: 104 deg F.

4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

B. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.

1. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150W.

   a. Restrike Range: 105- to 130-V ac.
   b. Maximum Voltage: 250-V peak or 150-V ac RMS.

2. Minimum Starting Temperature: Minus 40 deg F.

2.5 HID LAMPS

A. High-Pressure Sodium Lamps: ANSI C78.42, CR1 21 (minimum), color temperature 1900 K, and average rated life of 24,000 hours, minimum.

1. Dual-Arc Tube Lamp: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate S to 15 percent of normal light output.

2.6 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Structural Characteristics: Comply with AASHTO LTS-4.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 'Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.

2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the qquivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions; Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.

3. Anchor-Bolt Template: Plywood or steel.

D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-in-Place Concrete."

E. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.7 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429, Alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.

1. Shape: as shown on drawings.

2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 16 Section "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

D. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.

1. Finish: Same as pole.

E. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.

3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

4. Class 1, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

PART 3 – EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.

3.2 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 3 Section "Cast-in-Place Concrete.

C. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.

2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.

3. Install base covers, unless otherwise indicated.

4. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 16 Section "Raceways and Boxes.' In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 GROUNDING

A. Ground metal poles and support structures according to Division 16 Section "Grounding and Bonding."

1. Install grounding electrode for each pole, unless otherwise indicated.

2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage, Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

1. Verify operation of photoelectric controls.

3.6 DEMONSTRATION

A. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION

SECTION 16902
ELECTRIC CONTROLS AND RELAYS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation all electric controls and relays as specified herein and indicated on the Drawings.

B. Electrical control and relay systems shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with TEC standards is not acceptable.

C. Motor control circuits shall be wired in accordance with the requirements specified herein or indicated on the Drawings.

D. Reference Section 16000, Basic Electrical Requirements and. Section 16195, Electrical Identification.

E. The Contractor shall furnish and install, as specified herein and indicated on the Drawings, all motor control components and wiring for all motor-operated equipment furnished under this Section and all other Sections as indicated.

F. The Contractor shall furnish and install all external power and control wiring to control panels of prewired packaged equipment, unless indicated otherwise.

G. Control wiring requirements are indicated in electrical schematics and descriptions on the Drawings, in control functional descriptions which appear in Section 17900- Schedules and Control Descriptions, General of these Specifications, and in equipment manufacturer's equipment data. The Contractor shall furnish and install all control wiring in accordance with these Contract Documents. The Contractor shall provide all control circuits and wiring for a particular item of equipment in accordance with requirements as set forth by the manufacturer of the particular item of equipment.

H. As specified herein and indicated on the Drawings, furnish and install instrumentation wiring and connections to instrumentation equipment furnished under all Contracts of this Specification. Unless indicated otherwise, motor control switches, pilot lights, relays, and other control equipment for mounting in instrumentation panels shall be furnished, installed, and wired by the Contractor.

I. Where annunciators or other types of alarm systems are indicated as being furnished by others, the Contractor shall furnish and install the wiring and make connections to the alarm initiating device or contacts and to the annunciator. Where annunciators or alarm systems are indicated or specified in this Contract, the Contractor shall furnish and install the equipment and the complete wiring.

J. Where pumps provided by others are furnished with solenoid valves or other devices for control, the Contractor shall wire these valves or devices.

K. Unless otherwise specified herein or indicated on the Drawings, motor controllers shall be wired to drop out and remain dropped out on loss of power to the line side of the controller. Operator action shall be required to restart the motor unless the motor is intended to automatically restart.

L. Motor control components and control wiring shall conform to NEMA Specifications ISC-l970 (Revised, 1975), Industrial Controls and Systems.

M. Where devices are installed on the doors of NEMA 4, 4X, or 3R enclosures, devices shall be selected and installed to maintain the NEMA rating of the enclosure.

N. Wiring in all starters, panels, junction boxes, and similar equipment shall be brought out to numbered terminal strips for interconnection. The Contractor shall be responsible for documenting terminal numbers for all starters, controls, panels, and similar equipment provided under the Contract. At the completion of the project, the Contractor shall submit a complete set of record drawings showing and/or listing all terminals in boxes, panels, starters, and similar equipment in a single, complete bound package for the equipment and control supplied under the Contract Reference the General Conditions.

O. The Contractor is responsible for coordinating the electrical work under the Contract with all equipment starters, controls, and instruments provided under the Contract. The Contractor shall verify and coordinate all process equipment power supply and voltage, process equipment control power supply and voltage, and details of installation and interconnection. Coordination shall include distribution of approved electrical shop drawings to all Contractors.

P. Electrical control schematic diagrams drawn using a ladder-type format in accordance with JIC standards shall be submitted for all electrical equipment which is being provided under the Contract.

Q. Record drawings shall be provided in accordance with requirements in the General Conditions. One complete set of record wiring diagrams encased in plastic or plexiglass envelopes shall be provided for each starter, panel, and similar equipment. The diagrams shall include wire color codes showing connections from numbered terminal blocks to external equipment.

R. Where space or strip heaters are provided within the enclosures for electrical equipment, the Contractor shall make connections to these heaters from an appropriate power source and operate the heaters with temperature control as necessary until the equipment is installed and operated according to its intended use.

S. Control stations shall be furnished and installed at each motor and at all other controlled devices (e.g. solenoid valves) as specified herein and indicated on the Drawings.

1.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

a. None required.

2. Field Tests

a. Field tests shall be performed in accordance with the requirements specified in the General Conditions, Division I, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 SUPPLIES AND SPARE PARTS

A. The electrical control and relay systems and accessories shall be furnished with all spare parts as recommended by the equipment manufacturer and shall be furnished to the Owner by the Contractor.

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.

D. Spare parts lists, included with the shop thawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Term such as "1 lot of packing material" are not acceptable.

E. Parts shall be completely identified with a numerical system to facilitate parts control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

PART 2 - PRODUCTS

2.01 CONTROL COMPONENTS

A. Pushbuttons (PB) and selector switches (SS) shall be Type SK as manufactured by Square D Company, Type E34 as manufactured by Cutler-Hammer, General Electric Company equivalent, or equal. Pushbuttons and selector switches shall be 30.5 mm, heavy-duty, oil tight NEMA 4X corrosion resistant with legend plates as specified herein, indicated on the Drawings, or otherwise directed by the Engineer. Legend plates shall be plastic, black field (background) with white lettering. Pushbuttons and selector switches shall be non-illuminated. Pushbuttons shall include a full guard. Panic stop/alarm pushbuttons shall be red mushroom type with manual-pull release.

B. Pushbuttons and selector switches for all electrical equipment shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

C. Pushbuttons, selector switches, and other pilot devices for pump control panels shall be as specified herein and in the control functional descriptions which appear in Section 17900 - Schedules and Control Descriptions, General, and as shown on the Drawings.

D. Engraved nameplates shall be securely fastened to the front of each pushbutton station, disconnect switch, and motor starter remotely located from the motor control center. If adequate space is not available, the nameplate shall be mounted below the push button station. Nameplates shall be as specified in Section 16195, Electrical Identification. Identify all switches, control stations, and motor controllers as to their respective equipment.

E. Pilot lights shall be Square D Company Type SK, Cutler Hammer Type E34, General Electric Company equivalent, or equal. Pilot lights shall be of the proper control voltage, LED type, heavy-duty, corrosion-resistant NEMA 4X with legend plates as specified herein, indicated on the Drawings, or otherwise directed by the Engineer. Legend plates shall be plastic, black field (background) with white lettering. Pilot light lens colors shall be as follows:

Red - "Run", "On", "Open"
Green - "Off", "Closed"
Amber - "Alarm", "Fail"

F. Pilot lights for all electrical panels shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

G. Pilot lights for pump control panels shall be round with custom engraved legend plates for each pilot light.

H. Control Relays (CR) shall be Type KU as manufactured by Square D Company, Potter-Brumfield equivalent, Allen-Bradley equivalent, or equal. Relays shall be general purpose plug-in type with coil voltage as shown on the Drawings and sealed 10 ampere contacts. All relays shall have three SPDT contacts rated 120/240 VAC and 28 VDC minimum. Machine tool relays shall be provided when the contact burden exceeds 10 amperes. Miniature type or "ice cube" relays are not acceptable.

I. Timing Relays (TR) shall be the general purpose plug-in type, Type JCK as manufactured by Square D Company, Cutler-Hammer equivalent, Allen-Bradley equivalent, or equal. Timing relays shall be electronic type with 120 VAC coils unless otherwise specified or indicated on the Drawings. Timers shall be provided with two SPDT timed output contacts. Contact ratings shall be the same as for control relays as specified above.

J. Control Stations (CS) shall. be manufactured by Square. D Company, Cutler- Hammer, General Electric Company, or equal. Control stations shall be furnished and installed complete with pushbuttons, selector switches, and other pilot devices as specified herein or indicated on the Drawings. Stop push buttons shall be furnished with a lock-out device as specified herein and indicated on the Drawings. Control station enclosures shall be east aluminum with gasketed cover for all indoor dry areas. Control station enclosures shall be NEMA 4X stainless steel or nonmetallic with gasketed cover for all indoor damp/wet process areas. Control station enclosures shall be NEMA 4X stainless steel with gasketed cover for all outdoor applications. Control stations located in hazardous locations shall be suitable for the Class, Division, and Group to suit the application. The pilot devices shall be the factory sealed type mounted in enclosures as specified above.

K. Open type motor starters shall be rated 480 VAC, 3-pole, sized for the intended load unless otherwise indicated. Jnrio case shall a starter smaller than a NEMA Size I be used. Each starter shall be furnished with a minimum of two spare auxiliary contacts in addition to the hold-in contact. The motor starters shall conform to NEMA Standard IC 1 and shall be for across-the- line starting, unless otherwise indicated. IEC rated equipment is not acceptable and shall be used as a basis for rejection of the equipment. Starters shall be furnished with manual reset overload relays in each phase sized in accordance with the NEC. Provide door mounted overload reset button with metal (not plastic) shaft. Starters shall be provided with coils for 120 VAC operation, unless otherwise indicated on the Drawings. Ambient compensated, thermal, bi-metallic type overload relays shall be furnished and installed providing Class 20 operation. Overload relays shall be equipped with one additional normally open (NO) and normally closed (NC) isolated contact for use as specified herein or indicated on the Drawings. Solid state overload relays shall

only be furnished and installed if specifically accepted by the Engineer. The Contractor shall furnish and install correctly sized overload heaters based on the rating of the motor installed. Open type magnetic motor starters shall be Square D Company Class 8536 or 8736, Cutler-Hammer Type AN 16 or AN5 6 using NEMA rated Freedom Series contactors, General Electric Company equivalents, or equal.

L. Selected motors are indicted as requiring elapsed time indicators. Provide Eagle Signal Type HK2 1 0A6, General Time Catalog #ED27NR, Allen-Bradley equivalent, or equal, elapsed time indicators for 120 VAC volt operation mounted flush in the respective motor starter compartment door. Where clearance is not obtainable for compartment door closing, mount timers in a separately mounted enclosure, with each timer nameplated. Wire elapsed time indicator to operate when the respective motor operates.

M. Terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the enclosure or cabinet subpanel. Terminals shall be tubular screw type with pressure plate for wire size #22 - #8 AWG. Power terminal blocks shall be single tier with a minimum rating of 600 volts, 30A. Signal terminal blocks shall be single tier with a minimum rating of 600 volts, 20A. Separate terminal strips shall be provided for each type of power and signal used within each cabinet. There shall be a sufficient quantity of terminals for the termination of all spare field conductors. Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for incoming field conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal. Subject to the approval of the Engineer, a vendor's preengineered and prefabricated wiring termination system may be acceptable. The terminal blocks shall be as manufactured by Phoenix Contact, Inc., Wieland, Inc., Square D Company, or equal.

N. Alarm horns shall be as manufactured by Federal Signal Corporation, Edwards Signaling Company, EST (Edwards Systems Tech) or equal. Alarm horns shall be made for surface, flush, or semi-flush mounting on walls, panels, enclosures, or on square outlet boxes. Alarm horn sound output level shall be of 100dB (nominal) at 10 feet.

PART 3 - EXECUTION

3.01 CONFIGURATION OF CONTROLS AND EQUIPMENT

A. All controls including wiring, control switches, pushbuttons, indicating lights, control interlocks and similar devices, shall be provided at the control voltages specified herein or indicated on the Drawings. Each motor starter shall be provided with a control power transformer mounted in the starter unit. Primary wiring to the control power transformer shall be tapped to two (2) poles on the load side of the circuit breaker or fusible switch. Both primary wires shall be fused with 10- ampere, slow- blow fuses. The fuse on the ungrounded secondary side shall be capable of handling 100 percent to 125 percent of the rated control transformer secondary current. Control power transformers shall be provided with volt-ampere (VA) ratings equal to a minimum of 125 percent of the volt-ampere (VA) load connected to the transformer.

B. All equipment, cabinets, and devices furnished under this Contract shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models which are

currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion.

C. All equipment shall be designed to operate on a 60 Hz alternating current power source at a nominal 117 volts, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the; above shall be provided.

D. All switches shall have double-pole, double-throw, contacts rated at a minimum of 600 VA, unless specifically noted otherwise.

E. Materials and equipment used shall bear a U.L. label wherever such labeling of equipment and materials are available.

F. Unless otherwise specified or indicated on the Drawings, all equipment shall be designed, furnished, and installed So that in the event of a power interruption, the equipment must be restarted manually after a power failure.

G. All power terminals shall be insulated and identified.

H. All instruments shall operate at 10 to 125 degrees F unless otherwise specified. Internal wiring within all starters, panels, instruments, junction boxes and similar equipment, shall be brought out to numbered terminal strips for interconnection and field wiring.

J. All control components shall be mounted in a manner that will permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component's mounting shall be oriented in accordance with the component manufacturer's and industries standard practices. All internal components shall be identified with suitable plastic or metal engraved tags attached with drive pins adjacent to (not on) each component identifying the component in accordance with the Drawings, Specifications, and supplier's data.

K. Unless otherwise noted, the Contractor shall provide all interconnecting wiring and conduit for complete control systems. The Contractor shall make all connections to equipment devices, instruments, and all components requiring electrical connection.

L. The shield on each instrumentation cable shall be continuous from source to destination and shall be grounded as directed by the manufacturer of the instrumentation equipment. In no case shall more than one ground point be employed for each shield. All analog control functions shall utilize 4-20 mADC control signals, unless otherwise specified. All analog transmission shall take place within shielded twisted cables which are not susceptible to interference or noise.

M. Lightning/surge protection shall be provided to protect the instrumentation and control system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and shall be

maintenance free and self-restoring. Equipment shall be housed in a suitable metallic case, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and, where practical, each ground wire run individually and insulated from each other. These protectors shall be mounted within the enclosure or in a separate NEMA 4 junction box coupled to the enclosure.

3.02 FIELD TESTS

A. The Contractor shall conduct field tests prior to operation of the equipment. The Engineer shall witness all field testing. Field testing shall be conducted at a time approved by the Engineer. Field tests shall be conducted for all hardware components and shall include a functional check of all items. Field tests shall include a functional check of all instruments and control equipment. All equipment shall be connected and fully operational for field testing. Field tests shall demonstrate that the controls perform according to the Contract requirements and that all equipment, valves, switches, controls, alarms, interlocks, indicating lights, and similar equipment function properly. Based on the results of field tests, the Contractor shall make any required corrections to equipment and controls and shall make any adjustments required to the control logic and control settings to achieve the specified operation or operation otherwise directed by the Engineer. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. The Contractor shall make modifications and adjustments to the controls as directed by the Engineer for optimizing operation of the overall system. All costs in connection with field tests of equipment provided under the Contract shall be borne by the Contractor. The Contractor shall be fully responsible for the proper operation of all motor starters and controls during the tests.

END OF SECTION

SECTION 16910
CARD READER KIOSK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division I Specifications, apply to this section.

1.2 SUMMARY

A. This section includes the card reader kiosk unit and software, along with all of its related components and installation.

1.3 PERFORMANCE REQUIREMENTS

A. GENERAL:

1. The kiosk system shall be capable of automatically authorizing, recording and track all vehicles entering the truck wash facility.

2. The system should be compatible with all automated wash equipment used in the wash facility.

3. The software and kiosk should be able to be fully integrated and compatibale with the current Atlantic County Utilities Authority Trak Fuel Management System, Trak vehicle and personnel memory keys.

4. The Kiosk system shall be capable of being accessed by Trak memory keys, proxy/magnetic cards, fuel cards and personal identification numbers.

1.4 SUBMITTALS

A. Product Data: In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer and submit shop drawings and spec sheets for each component of the card reader kiosk system.

B. Operation and Maintenance Data: Include emergency, operation and maintenance manuals for entire system.

C. Each submittal shall be identified by the applicable specification section.

1.5 QUALITY ASSURANCE

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.6 DELIVERY, STORAGE AND HANDLING

A. Comply with manufacturer's instructions for storage and handling

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Trak Engineering Inc.
2981 Crescent Dr.
Tallahasse, FL 32301
(850) 878-4585
www.trakeng.com

B. The use of Track Engineering catalog/model numbers, and the specific requirements set forth herein and on the drawings are not intended to preclude the use of another manufacturer's products or procedures, but are given for the purpose of establishing a minimum standard of design and quality for materials, construction and workmanship. Other manufacturers that are to be considered must be submitted in accordance with the provisions indicated in Supplemental Instructions to Bidders contained in the Project Manual.

2.2 PRODUCTS

A. Trak Engineering Car Wash Controller

2.3 EQUIPMENT

A. Communications

1. Communications with the central controller is via fiber optic lines, current loop or RF.

2. On a regularly basis the central controller shall call up the car wash system controller and download records of all vehicles washed and any attempts at entry, including any attempts by unauthorized personnel to gain access.

B. Functional Electronics

1. Electronics all solid state, single board.

2. Display 40 character alphanumeric LCD with backlight.

3. Temperature Control Thermostat controlled, internal heater.

C. Electrical Requirements

1. Supply Voltage: 115 VAC

2. Supply Current: 100 ma maximum, 50 nominal

3. Power Consumption: 10 watts max., 5 watts nominal

4. Interconnect Direct Wire

5. Single Lines Fiber optic

PART 3 - EXECUTION

3.1 EXAMINATION

A. Materials and equipment used shall bear a U.L. label wherever such labeling of equipment and materials are available.

B. Unless otherwise specified or indicated on the Drawings, all equipment shall be designed, furnished, and installed So that in the event of a power interruption, the equipment must be restarted manually after a power failure.

C. All power terminals shall be insulated and identified.

D. All control components shall be mounted in a manner that will permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component's mounting shall be oriented in accordance with the component manufacturer's and industries standard practices. All internal components shall be identified with suitable plastic or metal engraved tags attached with drive pins adjacent to (not on) each component identifying the component in accordance with the Drawings, Specifications, and supplier's data.

E. The control functional descriptions which appear in Section 17900 - Schedules and Control Descriptions, General indicate interconnections between panels, instruments, and similar equipment. Unless otherwise noted, the Contractor shall provide all interconnecting wiring and conduit for complete control systems. The Contractor shall make all connections to equipment devices, instruments, and all components requiring electrical connection.

F. Lightning/surge protection shall be provided to protect the instrumentation and control system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and shall be maintenance free and self-restoring. Equipment shall be housed in a suitable metallic case, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and, where practical, each ground wire run individually and insulated from each other. These protectors shall be mounted within the enclosure or in a separate NEMA 4 junction box coupled to the enclosure.

G. Reference Division 17 - Control and Information Systems for additional information regarding lightning/surge protection requirements.

H. Consult with equipment supplier to confirm wash controller conformance.

3.2 SYSTEM INSTALLATION

A. All components are to be installed as to manufacturer's recommendations and to satisfaction of ENGINEER/OWNER

3.3 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions.

B. Occupancy Adjustments: When requested within 12 months of data of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside of normal occupancy hours for this purpose.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owners maintenance personnel to adjust; operate, and maintain controls and pumps. Refer to Division 1 Section Closeout Procedures and Demonstration and Training.

END OF SECTION

SECTION 16910
CARD READER KIOSK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division I Specifications, apply to this section.

1.2 SUMMARY

A. This section includes the card reader kiosk unit and software, along with all of its related components and installation.

1.3 PERFORMANCE REQUIREMENTS

A. GENERAL:

1. The kiosk system shall be capable of automatically authorizing, recording and track all vehicles entering the truck wash facility.

2. The system should be compatible with all automated wash equipment used in the wash facility.

3. The software and kiosk should be able to be fully integrated and compatibale with the current Atlantic County Utilities Authority FuelForce Management System, FuelForce vehicle and personnel memory keys.

4. The Kiosk system shall be capable of being accessed by FuelForce memory keys, proxy/magnetic cards, fuel cards and personal identification numbers.

1.4 SUBMITTALS

A. Product Data: In accordance with the procedures and requirements set forth in the General Conditions, the Contractor shall obtain from the equipment manufacturer and submit shop drawings and spec sheets for each component of the card reader kiosk system.

B. Operation and Maintenance Data: Include emergency, operation and maintenance manuals for entire system.

C. Each submittal shall be identified by the applicable specification section.

1.5 QUALITY ASSURANCE

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.6 DELIVERY, STORAGE AND HANDLING

A. Comply with manufacturer's instructions for storage and handling

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Multiforce Systems Corporation
101 Wall Street
Princeton, NJ 08540
(609) 683-4242
www.fuelforce.com

B. The use of Multiforce Systems Corporation catalog/model numbers, and the specific requirements set forth herein and on the drawings are not intended to preclude the use of another manufacturer's products or procedures, but are given for the purpose of establishing a minimum standard of design and quality for materials, construction and workmanship. Other manufacturers that are to be considered must be submitted in accordance with the provisions indicated in Supplemental Instructions to Bidders contained in the Project Manual.

2.2 EQUIPMENT

A. Communications

1. Communications with the central controller is via fiber optic lines, current loop or RF.

2. On a regularly basis the central controller shall call up the car wash system controller and download records of all vehicles washed and any attempts at entry, including any attempts by unauthorized personnel to gain access.

B. Functional Electronics

1. Electronics all solid state, single board.

2. Display 48 character alphanumeric LCD with backlight.

3. Temperature Control Thermostat controlled, internal heater.

C. Electrical Requirements

1. Supply Voltage: 115 VAC

2. Supply Current: 100 ma maximum, 50 nominal

3. Power Consumption: 10 watts max., 5 watts nominal

4. Interconnect Direct Wire

5. Single Lines Fiber optic

PART 3 - EXECUTION

3.1 EXAMINATION

A. Materials and equipment used shall bear a U.L. label wherever such labeling of equipment and materials are available.

B. Unless otherwise specified or indicated on the Drawings, all equipment shall be designed, furnished, and installed So that in the event of a power interruption, the equipment must be restarted manually after a power failure.

C. All power terminals shall be insulated and identified.

D. All control components shall be mounted in a manner that will permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component's mounting shall be oriented in accordance with the component manufacturer's and industries standard practices. All internal components shall be identified with suitable plastic or metal engraved tags attached with drive pins adjacent to (not on) each component identifying the component in accordance with the Drawings, Specifications, and supplier's data.

E. Unless otherwise noted, the Contractor shall provide all interconnecting wiring and conduit for complete control systems. The Contractor shall make all connections to equipment devices, instruments, and all components requiring electrical connection.

F. Lightning/surge protection shall be provided to protect the instrumentation and control system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and shall be maintenance free and self-restoring. Equipment shall be housed in a suitable metallic

case, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and, where practical, each ground wire run individually and insulated from each other. These protectors shall be mounted within the enclosure or in a separate NEMA 4 junction box coupled to the enclosure.

G. Consult with equipment supplier to confirm wash controller conformance.

3.2 SYSTEM INSTALLATION

A. All components are to be installed as to manufacturer's recommendations and to satisfaction of ENGINEER/OWNER

3.3 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions.

B. Occupancy Adjustments: When requested within 12 months of data of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside of normal occupancy hours for this purpose.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owners maintenance personnel to adjust; operate, and maintain controls and pumps. Refer to Division 1 Section Closeout Procedures and Demonstration and Training.

END OF SECTION

SECTION 16950
ELECTRICAL SYSTEM TESTING AND COMMISSIONING

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. This Section specifies the work necessary to test, commission and demonstrate that the electrical work satisfies the criteria of these Specifications and functions as required by the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWFIERE

A. Technical Sections include requirements for factory testing, test standards, and test report submittals when such requirements are applicable.

1.03 STANDARDS

A. National Electrical Testing Association "Acceptance Testing Specifications for Electrical Power Distribution Equipment and System.

1.04 GENERAL

A. The work of this Section includes furnishing the labor, equipment and power required to support the testing specified in other Divisions of these Specifications. Electrical testing specified herein, and functional testing of all power and controls shall be completed before commencement of the 7-day test specified in Section 01650, Equipment Testing and Plant Startup. This scope may require the Contractor to activate circuits, shutdown circuits, and run equipment, make electrical measurements, replace blown fuses, install temporary jumpers, etc.

B. All testing shall be conducted in the presence of the Engineer.

C. Coordination

1. The Contractor is responsible for coordinating the testing of electrical equipment with all related concurrent contractors. In particular, close coordination and cooperation between the Contractor and the Subcontractors is required to ensure complete, trouble-free testing.

2. The Contractor shall make available to all of the Subcontractors, the electrical equipment (power and controls) required to test and operate all electrically-operated mechanical equipment.

1.04 SUBMITTALS

A. At least 30 days prior to testing any equipment, system or subsystem, the Contractor shall submit for review and approval a detailed test plan for the equipment, system or subsystem.

B. Separate test plans shall be submitted for each of the following systems:

1. Conductor Systems.

2. Grounding Systems.

3. Distribution Systems.

4. Process Control Wiring

5. Variable Frequency Drives

C. System/Component Function Test Plan

1. The test plan shall list all demonstrable functions in the order in which the tests will be performed.

2. The test plan shall list all test equipment necessary for each test (including calibration date, where applicable).

3. The test plan shall provide space in which to record the actual results of each test.

1.05 TESTING

A. The following test requirements are intended to supplement test and acceptance criteria that may be stated elsewhere in the specifications.

1. A functional test and check of all electrical components is required prior to performing subsystem testing and commissioning. Compartments and. equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing. Functional testing shall include:

a. Visual and physical check of cables, busswork, circuit breakers, transformers, and connections associated with all new and modified equipment.

b. Setting of protective relays in conformance with results of the studies and testing of relays listed in Section 16000 to assure that relays will trip at the current value and time required by the Study.

c. Circuit breakers which are specified with adjustable time or pick-up settings for ground current, instantaneous overcurrent, short-time overcurrent, or long-time - overcurrent, shall be field adjusted by a representative of the circuit breaker Manufacturer. Time and pickup setting shall correspond to the recommendations of the Short Circuit Study. Setting shall be tabulated and proven for each circuit breaker in its installed position; test results shall be certified by the testor and transmitted to the Engineer (7 copies).

d. Settings for the motor circuit protectors (which are specified with adjustable time or pick-up settings for ground current, instantaneous overcunent, short-time overcurrent, or long-time overcurrent, shall be field adjusted by a representative of the circuit breaker Manufacturer. Time and pickup setting shall correspond to the recommendations of the Short Circuit Study. Setting shall be tabulated and proven for each circuit

breaker in its installed position; test results shall be certified by the testor and transmitted to the Engineer (7 copies).

e. Verification of expected bus loads on existing switchgear will be checked.

B. Subsystem testing shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the Engineer and after process control devices have been adjusted as accurately as possible. It is intended that the Contractor will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results. Subsystems, in the context discussed here, shall mean individual and groups of pumps, etc.

1. After initial settings have been completed, each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract Documents. Once the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc. In this instance, automatic operation shall contain, but not be limited to: interlocks to the operator control station and the control panels.

2. Existing motor operated valves shall be tested after having been phased and tested for correct motor rotation and after travel and torque limit switches have been adjusted by a representative of the valve Manufacturer. Tests shall verify status indication, proper valve travel, and correct command control from local and remote devices.

3. Variable speed drives shall have the following tests performed (as a minimum):

   a. All chive settings verified by the pump, motor and drive vendors to ensure that the drive will perform properly under all load conditions.
   b. Individual drives and drive combinations shall be monitored at the point of common coupling to ensure their compliance with the results of the harmonic study listed in Section 16000.

4. Proposed and existing field devices connected to pump starters shall be tested for continuity. These items shall include, but not be limited to:

   a. Limit switches on valves
   b. Pressure switches.

5. Correct sequencing of valves shall be verified to ensure that the proper valve opens and closes when the appropriate duty or standby pump is called to run

6. Correct status and command indication shall be verified at the Operator Control Station and the Control Panel

1.05 COMMISSIONING

A. Commissioning during the 7-day test as specified in Section 01650, Equipment Testing and Plant Startup; shall not be attempted until all subsystems have been found to operate

satisfactorily; commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable. Simulation of process - parameters shall be considered only upon receipt of a written request by the Contractor.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01 CONDUCTOR SYSTEMS

A. Insulation Testing Test in accordance with the applicable portions of Section 16000 and 16123.

B. All conductors shall be tested for continuity, connections shall be checked for tightness, and conductor identifications shall be verified for correctness.

C. For shielded instrumentation and control cables, verify that the shields are isolated from ground except at the grounding point. Remove all improper grounds at no additional cost to the Authority.

3.02 GROUNDING SYSTEM

A. Visual and Mechanical Inspection- Verify that ground system is in accordance with drawings and specifications.

B. Electrical Tests

1. Perform point to point tests to determine the resistance between the 480V switchgear and the proposed power distribution panels, equipment frames, and all separately derived systems furnished under this contract.

2. Verify that no bearing currents are caused by VFD operation.

C. Verify the continuity of all bonding jumpers.

3.03 PROCESS CONTROL WIIUNG

A. Test all wiring circuits between process control equipment panels for continuity and insulation (megger test).

B. Coordinate with the General Construction Contractor during the performance of mechanical equipment testing.

3.04 REPAIRS

A. The Contractor shall promptly repair or replace any equipment, which appears to be defective or fails any of the specified tests.

B. Repaired or replaced items shall be tested after installation. The Engineer may• require the restart of any system test based on failure to individual items.

3.05 THERMAGRAPIHC INSPECTION

A. Thermagraphic Inspection

1. Perform thermagraphic inspection of the electrical equipment and installations listed herein in the presence of a duly authorized representative of the Engineer.

2. The purpose of the thermagraphic inspection is to locate; by comparisons of temperature levels, high resistive points in installation of electrical materials and equipment. Comparisons are made by referencing a known ambient temperature of the object being scanned to the hot spot detected.

3. The detection equipment shall consist of an infrared camera that has a range between -20 degrees C and 900 degrees C with an accuracy of 0.1 degrees C.

4. Equipment Operator: Engage the service, of a specialist who has at least one year of actual experience operating thermagraphic equipment of the type listed below:

   a. Existing Low Voltage Switchgear and connections of proposed power panels to existing switchgear.
   b. Any proposed distribution transformers shown on the contract drawings.
   c. Distribution Panelboards.
   d. Variable Speed Drive Cabinets.
   e. Variable Speed Drive Motors installed under this contract.

3.06 TEST ADMINISTRATION

A. The contractor shall prepare all procedures and forms used in the test reports and shall submit them to the engineer for approval prior to commencement of testing. The test report shall contain:

1. Job title.
2. Date of test.
3. Equipment or system or cable identification.
4. Specific type of test.
5. Description of test instrument.
6. Section of specification defining the test along with a description of the test and evaluations as reported by the testing company.
7. Test results (correct all Megger readings to 20 degrees C.
8. Signature of person supervising the test.
9. Signature of contractor.

B. Within ten (10) days after completion of Contract, notify the Engineer of proposed testing dates.

C. Do not perform any tests until the test plan has been approved by the Engineer.

D. Do not perform any tests unless at least two qualified Water Department observers (Inspectors/Engineers) are present.

E. Make available all technicians, labor, equipment and materials to perform the tests. Document calibration dates, where required.

F. Perform all tests in accordance with the approved test plan, in an orderly manner, and record the results neatly.

G. Obtain the signatures of the Authority observers upon completion of each day's tests.

3.07 ACCEPTANCE

A. Promptly submit three (3) copies of the completed test report, certified correct by the Contractor. Raw test data is acceptable.

B. Upon completion of the function tests, a four-day operational test will be performed by the ACUA.

C. Should any deficiencies be discovered during the function or operational tests, promptly make all required repairs and repeat the function tests involved.

D. The completed installation will be accepted upon successful completion of all function and operational tests, correction of all defects and approval of all tests reports.

END OF SECTION